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DEVELOPMENT AND EVALUATION OF A TRANSPORTATION CONTROL PLAN FOR THE MASSACHUSETTS PORTION OF THE HARTFORD-NEW HAVEN-SPRINGFIELD AIR QUALITY CONTROL REGION

VOLUME I. PROPOSED TRANSPORTATION CONTROL PLAN

GCA Corporation

PREPARED FOR
Environmental Protection Agency

September 1975

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16. ABSTRACT This document describes the development and evaluation of a Transportation Control Plan for the Springfield Air Quality Study Area (AQSA), consisting of the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region. The effort reported here is an extension and modification of prior work to define the transportation control measures to attain the carbon monoxide standard in the City of Springfield, and in addition develops control measures for hydrocarbon emissions throughout the AQSA.

Discussion and analysis is included on air quality, emissions, methods for forecasting future emissions and air quality, evaluation of control measures, plan surveillance, and schedules for implementation. Each alternative control measure was assessed for its social and economic impacts and associated legal and administrative issues as well as for its effectiveness at reducing pollutant emissions. A specific package of control measures is recommended, including added control of stationary hydrocarbon sources and traffic flow management techniques for control of carbon monoxide in Springfield.

This report was submitted in fulfillment of Contract No. 68-02-1376, Task Order Nos. 10 and 15, by GCA/Technology Division, Bedford, Massachusetts, under the sponsorship of the U.S. Environmental Protection Agency. Work was completed in April 1975.

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Volume I

Proposed Transportation Control Plan

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Under Joint Sponsorship of
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SECTION I

SUMMARY AND PREAMBLE*

INTRODUCTION

The U.S. Environmental Protection Agency is considering a number of amendments to the transportation control plan that it promulgated on November 7, 1973 (38 FR 30827), for the Massachusetts portion of the Hartford-New Haven-Springfield Interstate Air Quality Control Region (referred to in this report as the Springfield Air Quality Study Area or AQSA). These amendments result from a re-study of the air quality needs of the AQSA, which was prompted by air quality monitoring data that has become available since the original TCP was promulgated. Some of the changes also reflect conclusions EPA has drawn in connection with its administrative experiences to date in implementing this and other control plans. In preparing these amendments, EPA and its consultant have drawn upon consultations with a variety of affected state, local, and regional officials.

Included in the new proposed transportation control plan are measures related to both local concentrations of carbon monoxide and regional concentrations of photochemical oxidants. Control measures include stationary source controls, carpool matching service, traffic flow improvements for the Springfield Central Business District, and a program of inspection and maintenance of in-use vehicles. Several of these measures are modifications to those in the original Springfield TCP or are outgrowths of statewide pollution control programs being developed by the Commonwealth of Massachusetts.

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*This section is intended to serve as a summary of this report and as a draft of the preamble to a Federal Register notice to promulgate the proposed Transportation Control Plan. Where possible, this section draws from the preamble of the draft Boston TCP (40 FR 8668, February 28, 1975).

BACKGROUND

The Clean Air Act requires EPA to establish national "primary" air quality standards strict enough to protect all members of the population from adverse health effects caused by air pollution, including carbon monoxide and photochemical oxidants. It then requires each state to have in effect an "implementation plan" to achieve these standards throughout its territory by 1975, or 1977 at the latest, or by some intermediate date as is the case for the Springfield AQSA (the Springfield AQSA was granted an extension to 1 August 1976 for attainment of carbon monoxide standards). If a state does not submit an appropriate implementation plan, the Act requires EPA to promulgate an appropriate plan for the state.

Although the Massachusetts plan was substantially approvable for non-automobile-related pollutants, it did not provide for meeting the oxidant and carbon monoxide standards by May 31, 1975. The automobile is the source of nearly all carbon monoxide and a majority of the hydrocarbons which form photochemical oxidants. Although the Federal Motor Vehicle Emissions Control Program ("FMVECP") established by the Clean Air Act requires all new automobiles to meet strict emission standards for these pollutants, calculations show that this program by itself would not have assured that the national primary air quality standards necessary to protect public health would be met throughout the Springfield AQSA by the 1975 date mandated by the Act. Therefore, the implementation plan for the Springfield AQSA must contain land use and transportation controls in order to be approved by EPA. Instead of including such measures, however, Massachusetts asked for an extension of time in which to supply the missing portions of its plan and an extension of time in which to achieve the standards. On May 31, 1972 (37 FR 10842), pursuant to section 110 of the Clean Air Act and 40 CFR Part 51, the Administrator approved, with specific exceptions, the Massachusetts state implementation plan and approved the requests for extensions of time.

On January 31, 1973, the United States Court of Appeals for the District of Columbia Circuit found that the Administrator did not conform to the strict requirements of the Clean Air Act in granting Massachusetts and several other states their extensions. Accordingly, the Court ordered the Administrator to rescind the extensions. The Administrator complied on March 20, 1973 (38 FR 7327), and Massachusetts was required to submit a transportation control plan by April 15, 1973, as specified by the court. Because the Commonwealth did not submit its plan by that date, EPA contracted with a consulting firm, GCA/Technology Division, to prepare a TCP for Springfield. After reviewing the GCA report and holding public hearings, EPA promulgated the Springfield TCP on November 7, 1973 (38 FR 30827). The plan called for the control of carbon monoxide emissions in the Springfield downtown area (only) through parking limitations and a parking surcharge in Springfield, computer carpool matching, traffic flow improvements in the Springfield downtown area, closing a section of Main Street in Springfield to all private passenger cars, and semiannual inspection and maintenance of light-duty vehicles. The attainment date for CO standards was extended to August 1, 1976 (38 FR 30964, November 8, 1973).

Subsequent to the promulgation of the Transportation Control Plan, it was determined, through additional monitoring, that the standard for photochemical oxidant concentrations was also being exceeded in the Massachusetts portion of the AQCR. In light of this, the Governor of the Commonwealth was notified on February 14, 1974, by letter through the Region I Administrator, that a plan would have to be developed to reduce photochemical oxidant concentrations accordingly. (The legal deadline for attainment of the oxidants standard remains as 31 May 1975; it can be presumed that the Commonwealth will request an extension of this deadline.) Because of the availability of additional data it was decided to review the promulgated Transportation Control Plan for downtown Springfield concurrently with the development of the control plan for photochemical oxidants, and update or revise the plan accordingly.

TECHNICAL BASIS FOR THE PROPOSED CONTROL PLAN

The Transportation Control Plan proposed here was developed during a second study by EPA's consultants, GCA/Technology Division, of the Springfield AQSA and its air quality needs. The remaining sections of this report present the procedures, data, and results of the study and provide the technical basis for the proposed revision to the TCP. The major sections of the report will be briefly summarized here.

Summary of the Technical Analysis

Section II is an introduction to the report, and presents a summary of the background of the TCP, also reviewed above. Section II also describes the scope and overall procedures for the report, and defines the geographic area treated by the report. The study area (the AQSA) (and the area to which the proposed regulations would apply) consists of the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region. The AQSA is also known as the Pioneer Valley Air Pollution Control District, and encompasses Franklin, Hampshire, and Hampden Counties.

Section III of this report describes and assesses the present air pollution situation in the air quality study area. As noted earlier, discussion is limited here to carbon monoxide and oxidants. Section III includes discussions of the methods used for assessment of air quality and emissions; natural features and meteorology; present air quality; present emissions; and methods for estimation of future emissions and air quality.

Section IV presents a detailed discussion of the transportation control measures reviewed in this report. Each control measure is discussed individually. For each measure there is a detailed description and explanation for its selection, followed by a discussion of its effectiveness as a pollution-control measure, its social impacts, and its economic impacts. Legal and administrative aspects are also discussed, along with a summary of the assumptions used for estimating effects. Discussion includes all the alternatives reviewed for this plan.

Section V presents an analysis of the effects of implementing all of the proposed transportation control measures. Whereas Section IV discussed each measure individually, Section V treats the recommended measures collectively, as a "package," thus taking into account their interaction. Discussion includes the direct impacts on transportation and air pollution and also the social and economic effects.

Section VI presents the surveillance review process that will enable monitoring the progress of the plan's implementation as well as measuring the actual impact of the various strategies on air quality. In addition, important checkpoints are provided on a "milestone" chart indicating the critical actions, such as legislation or financing, that must be taken in order to implement the strategies.

Following Section VI are several appendices containing background information, detailed data, details of certain analyses discussed in the text and the proposed regulations for implementing the recommended plan.

Selected material from the text of the report is summarized in the material that follows in this section.

Air Quality Data

Monitoring - Currently there are two air quality monitoring sites in operation in the AQSA. One, in Amherst, monitors ozone only. A second, in downtown Springfield, monitors both carbon monoxide and ozone (and also other pollutants). Four other sites have been used in the past for monitoring of carbon monoxide, all located in the Springfield downtown area. Data for all six sites were reviewed for this report.

Carbon Monoxide Data - The national primary ambient air quality standard for carbon monoxide (CO) states that the 8-hour average level of 9 parts per million (ppm) can be exceeded only once per year. Table I-1 summarizes the CO data for Springfield that formed the basis for the development of the TCP. The table lists the highest and second-highest 8-hour average concentration at each site. The table shows that the highest CO concentrations recorded prior to preparation of this report occurred on December 26, 1973 (at two sites). The baseline value used for this report is the second-highest nonoverlapping 8-hour concentration occuring at Main and Hillman Streets, in this case 22.1 ppm. This reading is 59 percent in excess of the standard. On the basis of the linear rollback relationship used for this report, it would be necessary to reduce CO concentrations by 59 percent in order to meet the air quality standard at the Main and Hillman site.

Table I-1. CARBON MONOXIDE CONCENTRATIONS IN EXCESS OF 8-HOUR STANDARDS IN SPRINGFIELD, MASSACHUSETTS

Location	Highest 8-hour average			Second-highest 8-hour average[a]		
	Concentration, ppm	Date	Time[b]	Concentration, ppm	Date	Time[b]
Main and Hillman Sts.	22.8	12/26/73	2300	22.1	12/4/73	2100
E. Columbus Ave. Power House	21.5	1/11/72	2400	21.3	1/10/72	2200
E. Columbus Ave. Trailer	26.6	12/26/73	2300	19.3	1/19/73	2100

[a] Nonoverlapping 8-hour time periods.

[b] Hour ending the 8-hour period.

Carbon monoxide is a highly localized pollutant that is usually detected in high concentrations near the source of emissions, such as street intersections. Although the air quality data show the CO standards have been violated on many occasions at the monitoring sites in Springfield, it is difficult to generalize about CO concentrations at other locations in downtown Springfield, because CO concentrations can vary substantially over short distances. Because of this, the APRAC-1A diffusion model was used for simulating CO concentrations at 20 locations in downtown Springfield. This computer model allowed examination of the variation in CO concentrations among sites and facilitated evaluation of the traffic flow changes and other controls being considered for the TCP. The APRAC-1A model accounts for both the background concentrations of CO from diffusion and the concentration of CO from vehicles in the immediate vicinity of the location being evaluated. For present traffic conditions (1974 data) and with no controls, the APRAC-1A model showed that the site at Main and Hillman would be expected to have the highest CO concentrations of the 20 sites that were evaluated. Thus, with present traffic conditions, the required reduction in CO emissions for other locations in Springfield can be expected to be less than the 59 percent calculated above for the site at Main and Hillman.

Oxidants Data - The national primary ambient air quality standard for oxidants is 0.08 ppm (1-hour average), not to be exceeded more than once per year. Table I-2 summarizes the highest concentrations of oxidants recorded in Springfield in 1973 and 1974. Review of the monitoring site location and data led GCA to the conclusion that these data are valid in indicating that an oxidants problem exists in the AQSA, although they may not represent the maximum concentrations possible within the region.

Table I-2. HIGHEST 1-HOUR OXIDANT CONCENTRATIONS,[b] SPRINGFIELD, MASS.

Year	Highest concentration[a]			Second-highest concentration[a]		
	Concentration, ppm	Date	Time	Concentration, ppm	Date	Time
1973	0.145	June 16	1500	0.134	June 5	1900
1974	0.116	April 29	1900	0.108	June 30	1800

[a] 1-Hour average.

[b] Data for the period beyond December 1974 were not available for inclusion in this report.

Unlike carbon monoxide, photochemical oxidants are secondary pollutants that result from complex reactions of hydrocarbons and oxides of nitrogen, catalyzed by sunlight. Both hydrocarbons and nitrogen oxides are emitted by automobiles. The conversion of hydrocarbons can require several hours to several days - depending on the types of photochemical oxidant precursors, and meteorological conditions. Because of this, oxidants and their precursors may be transported over considerable distances, and as a result, the oxidant problem is addressed on a regional basis rather than at the local level. It has been speculated that, in some areas, high concentrations of oxidants may be attributable, in part, to transport either from the upper atmosphere or from upwind sources such as urban centers. While it appears that transport can contribute to oxidant concentrations, there is no implication that the contributions of local sources of oxidant precursors are of diminished importance.

In the absence of a fully developed method for accounting for oxidant photochemistry and transport, this report has followed past practice and used the proportional rollback technique for determining the degree of reduction needed in hydrocarbon emissions in order to achieve the oxidants standards. On the basis of the data in Table I-2, it was thus estimated that hydrocarbon emissions must be reduced by 40.3 percent to achieve the standard.

SUMMARY OF CONTROL MEASURES

Transportation control measures proposed in this report have evolved from technical analysis by GCA and consultations with EPA, state agencies, and regional and municipal officials. The proposed measures, together with the Federal Motor Vehicle Emissions Control Program, constitute a comprehensive strategy for attainment of both the CO and oxidants standards.

Proposed Measures

This TCP recommends controls of both emission sources (i.e., tail pipe controls) and of transportation patterns. In addition, added controls on stationary sources of hydrocarbons are recommended, as discussed separately in Volume II, "Hydrocarbon Emission Sources in Pioneer Valley." The stationary source controls are generally consistent with those recently promulgated for the Boston Metropolitan Intrastate AQCR (see 40 FR 25151, June 12, 1975) and will not be described further here.

It is recommended that the State Carpooling Program be utilized in the Springfield AQSA as a means of encouraging carpooling. The Commonwealth of Massachusetts has prepared an instruction manual showing how employers and educational institutions can reduce commuter mileage by forming carpools and vanpools. The manual will offer employers valuable information and should encourage the formation of a substantial number of carpools and vanpools. The Commonwealth has contracted with a consulting firm (the same firm which prepared the manual for the carpool program) that will employ a number of full-time carpool/transit specialists who will work with employers and educational institutions throughout the Commonwealth. In addition, the Commonwealth will make available a computer program for matching the names and travel patterns within large groups of employees or students and it is prepared to run such a program on a state-owned computer if a particular employer or educational institution should require the service. It is considered that these actions on the part of the Commonwealth are likely to result in substantial carpool and vanpool formations. For the Springfield AQSA participation in the program by employers may be on a voluntary basis although this issue has yet to be resolved.[*]

A program of improvements to the transit system was analyzed, although it is not part of the formal TCP. In essence, this report endorses a transit program recently developed by others for the Springfield area, with the addition of transit shuttle service connecting the Springfield CBD with parking lots on the fringe of the CBD. More specifically, the transit program elements would be:

1. Service Improvement
    a. Express service on four new routes, added service on present six routes, park-and-ride facilities at four locations.
    b. Bus route changes for both Springfield and Holyoke routes.
    c. New service, including new Springfield crosstown service, special employment access routes, and increased service to area colleges.
2. Passenger Amenities
    a. Bus shelters at 17 locations.
    b. Bus stop signs.
    c. Route maps and schedules.
    d. Marketing and promotion efforts, including promotional fares and prepaid pass systems.
3. Traffic-Transit Integration (as part of traffic flow management measure)
    a. Curb parking controls.
    b. Exclusive bus lanes.

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[*] A new analysis of the effectiveness of the carpool program was added to this final report; see Appendix K.

Traffic flow improvements are proposed as the major CO control technique, specifically for the Springfield CBD. Developed with the aid of the APRAC diffusion model, the program includes several elements:

1. One-way circulation system, involving Main Street and several other nearby streets in the CBD. One-way flow will reduce traffic volumes, increase speeds, and reduce emissions. Short segments of certain streets are proposed to be closed, and used exclusively as loading zones. A contra-flow bus lane would be used on Main Street.

2. Coordinated parking program, involving the elimination of curb parking from portions of six streets (total of 114 curb spaces), more restrictive limitations on remaining curb space and more rigorous enforcement, development of a parking lot beneath the Interstate-291 highway viaduct at the edge of the CBD, and prohibition of deliveries in certain areas during the afternoon peak travel period.

3. Spot physical improvements of signals, curbs, channelization, and similar measures related to safety and smooth traffic flow.

A program of mandatory inspection and maintenance (I&M) of all light- and medium-duty gasoline-powered vehicles registered within the AQCR was also analyzed as a control measure. During development of this plan a number of alternative configurations of the I&M Program were analyzed; however, the final decision as to which configuration was to be recommended for the AQCR, was made only recently. The decision was based on the desire to implement a uniform program within the Commonwealth; therefore the configuration selected for the Springfield AQCR is identical to that promulgated for the Boston AQCR (40 FR 26154, June 12, 1975). This program calls for annual inspection of all gasoline-powered light- and medium-duty (vehicles up to 10,000 lb GVW) vehicles, using the idle-mode test. Included are provisions requiring: (1) retesting of failed vehicles within 2-weeks of the initial test; (2) establishing an enforcement program, such as spot checking of idle adjustment; (3) establishing safeguards to protect the consumer from loss due to negligent performance of inspection and related maintenance work. It is expected that the I&M Program will eventually be integrated with the Commonwealth's existing safety inspection program.

Air Quality Impacts of the Proposed Measures

The collective effect of all the proposed TCP measures is summarized below, by pollutant. In the body of this report, these effects are discussed separately for each control measure.

Carbon Monoxide - The impact of the proposed controls on carbon monoxide concentrations in downtown Springfield will result mainly from changes in emission characteristics along individual streets. These changes will be effected by the redistribution of traffic and improved efficiency of traffic flow. The effects of these traffic flow changes, and of other controls including FMVECP and inspection/maintenance, were determined with the APRAC computer model for 20 specific locations in Springfield. The collective effect of these measures is summarized in Table I-3. Additional details are presented in the body of the report. As the table shows, locations with 1975 CO concentrations that exceed the standard are predicted to be acceptable in 1976. Although some locations will experience increases in CO levels because of traffic flow changes, the highest concentrations predicted for 1976 will be below the standard. Further reductions in CO concentrations are forecasted for future years as a result of FMVECP.

Hydrocarbons/Oxidants - Of the measures analyzed, only FMVECP (which is not optional and is thus not strictly a proposed TCP element) and inspection and maintenance would have substantial effect on regional hydrocarbons emissions from vehicular sources. Table I-4 summarizes the effects of inspection/maintenance and of the stationary source controls described in Volume II. Carpooling was omitted from the table because its effect will depend highly upon whether the program is voluntary or mandatory, which has not been resolved. A carpooling program that

Table I-3. PROJECTED CONCENTRATIONS OF CARBON MONOXIDE AT SELECTED LOCATIONS IN DOWNTOWN SPRINGFIELD, MASSACHUSETTS

Location (in Springfield, Massachusetts)	Projected highest and second-highest 8-hour average concentrations of CO, ppm[a]			
	December 31, 1975 with no controls[b]		August 1, 1976,[c] with proposed controls[d]	
	Highest	Second highest	Highest	Second highest
Main at Hillman[e]	15.87	15.78	3.58	3.57
Main at Vernon[f]	14.63	14.52	2.11	2.10
State at Chestnut[g]	5.88	5.85	8.58	8.56
W. Columbus at State[g]	6.08	6.05	8.58	8.55
E. Columbus at I-91[g,h] (northbound)	7.02	7.00	8.93	8.90

[a] Projections using APRAC-1a computer model.

[b] Includes effect of Federal Motor Vehicle Emissions Control Program.

[c] Required attainment date.

[d] Includes annual idle-mode inspection/maintenance with 40 percent failure rate.

[e] Location with highest measured or calculated concentrations without controls.

[f] Location with second-highest calculated concentrations without control.

[g] Examples of locations experiencing modest increase in CO concentrations as a result of traffic redistribution.

[h] Location with highest calculated concentrations in 1976 (with controls).

Table I-4. COMBINED STRATEGY EFFECTIVENESS IN REDUCING REACTIVE HYDROCARBON EMISSIONS IN FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emissions source category	Emissions source	Control concept	Estimated 1 Aug. 1976 emissions[a]		Emissions reduction achieved, kg/day	Reduction achieved as a percentage of source emissions, %	Reduction achieved as a percentage of total HC emissions, %
			Without[b] controls, kg/day	With proposed controls, kg/day			
Vehicular sources	Light-duty vehicle	Inspection and maintenance[c]	28,733	27,009	1,724	6.0	1.9
	Light-duty trucks	Inspection and maintenance[c]	7,704	7,180	524	6.8	0.6
	All other vehicles	None	10,157	10,157	–	0.0	0.0
Subtotals			46,594	44,346	2,248	4.8	2.5
Nonvehicular sources	Dry cleaning	Reformulate	194	0	194	100.0	0.2
	Degreasing	Reformulate	552	26	526	97.1	0.6
	Surface coating	Vapor recovery and control	29,060	6,058	23,002	79.2	25.4
	Manufacturing	Vapor recovery and control	2,913	680	2,233	76.7	2.5
	Bulk petroleum storage	Vapor recovery	326	226	100	30.7	0.1
	Fuel combustion	None	2,203	2,203	0	0.0	0.0
	Solid waste incineration	None	806	806	0	0.0	0.0
	Gasoline marketing	Vapor recovery and control	6,598	659	5,939	90.0	6.6
	Aircraft, LTD's	None	142	142	0	0.0	0.0
	Railroad and vessels	None	1,108	1,108	0	0.0	0.0
Subtotals			43,902	11,908	31,994	72.9	35.4
Totals			90,496	56,254	34,242	37.8	37.8

[a] Reactive hydrocarbon emissions only.

[b] With FMVECP only.

[c] Assumes idle mode, annual inspection interval, 40 percent failure rate; this is the most conservative configuration of inspection and maintenance analyzed and the one most likely to be implemented. Table assumes I/M would be fully effective by 1 August 1976 (i.e., that inspections began in August 1975).

achieves a 25 percent reduction in single-occupant automobile commuting (the goal of the Boston area program) could reduce emissions by an additional 1200 kg/day in 1976.

Also omitted from Table I-4 is the FMVECP. To determine the impact of FMVECP, one may examine how emissions are calculated to change over time without any other control measures. On December 31, 1973, the baseline date for this report, total vehicular emissions were calculated to be 52,912 kg/day. As shown in Table I-4, vehicular emissions on 1 August 1976 are expected to be 46,594 kg/day with only FMVECP in effect. Thus, FMVECP accounts for a reduction of 6,318 kg/day over that period (in spite of an increase in travel volumes). That reduction amounts to about 6.5 percent of what the total baseline (1973) emissions were.

As shown in the table, the collective effect of the control measures is to reduce emissions by 37.8 percent to 56,254 kg/day on the assumed compliance date. On the basis of a linear rollback model, it was found that the rate necessary to attain emission standards would be approximately 57,700 kilograms per day. Comparing the allowable emissions rate with the estimated emissions rate for 1 August 1976 (assuming all stationary and mobile source controls are in effect) it can be seen that the required reduction in hydrocarbon emissions is achieved with a slight factor of safety. Daily emission rates for selected years through 1985 are shown in the text.

Previous discussion indicated that oxidant concentrations reported for a particular area result from hydrocarbon emissions generated within that area plus transport of oxidants and precursors from upwind sources. In the Massachusetts portion of the AQCR, it is not likely that the entire oxidants problem is due to transport from upwind sources nor is it likely that oxidants and precursors generated within this area do not contribute to oxidant concentrations at locations downwind of the AQCR. The implications of transport are not that less stringent controls on emissions sources within the AQCR are appropriate, but rather that the scope of control plans should be expanded to include areas even larger than the AQCR's as they are currently defined. The analysis thus should be considered to show that the proposed control measures would reduce emissions in the Springfield AQSA enough to meet the ambient standard according to the best estimate now available, and that the control strategy should be modified as better information becomes available.

Effects of Changes in Attainment Schedule - The analysis summarized above was based upon (1) using the date of 1 August 1976 for oxidants, to be consistent with the attainment date for CO; and (2) assuming that all control measures could be fully implemented and in effect by 1 August 1976. These assumptions warrant further comment here and are discussed in more detail in Sections IV, V, and VI.

One key to the actual implementation schedule is inspection/maintenance, which is a major factor in the control plans for both CO and oxidants. The final Boston area TCP (40 FR 25161 ff) stipulates that vehicle inspections begin in August 1976. It is reasonable to assume that inspections will begin in the Springfield area no earlier than in Boston, and probably later. Thus, inspection/maintenance cannot be presumed to have any impact until after 1 August 1976, and cannot be presumed to be fully effective until after a full year of operation (probably after August 1977).

With respect to CO, the attainment date for which has been set as 1 August 1976, an analysis was performed of the implications of delays in inspection/maintenance. In the absence of inspection/maintenance, the other control measures are predicted to allow to CO standard to be attained sometime in 1977. If inspections are begun in August 1976, as in Boston, the CO standard would be met by 31 December 1976. In short, inspection/maintenance will allow earlier attainment of the CO standard if inspections are begun sometimes in 1976.

With respect to oxidants, the attainment date is legally 31 May 1975. For analysis, the draft report used 1 August 1976, to be consistent with the CO attainment date. This final report includes calculated hydrocarbon emissions for various dates. The date by which hydrocarbon emissions will be less than the estimated allowable rate will depend upon (1) the schedule for implementation of inspection/maintenance and (2) the degree of emission reduction from the carpooling program. If inspection/maintenance begins in August 1976, emissions would reach the allowable level sometime before 31 December 1976. If carpooling reduces the use of single-occupant vehicles by 25 percent, as is the goal in the Boston area, the allowable emissions rate could be achieved by 1 August 1976. It seems unlikely that such a carpooling rate will be achieved; thus, attainment later in 1976 seems likely.

PROPOSED CHANGES IN THE REGULATIONS

Appendix I of this report presents draft regulations for implementing the proposed Transportation Control Plan. Wherever possible the regulations are based upon comparable regulations for the Boston TCP (40 CFR 52.1128 ff, in 40 FR 25161) or the existing Springfield regulations (40 CFR 52.1148 ff). Each major regulation will be briefly described here.

Regulations related to control of hydrocarbon emissions from nonvehicular sources are described and analyzed in Volume II. These stationary source controls are proposed to be similar to those for the Boston Intrastate Region.

The regulation for computer carpool matching would require the Commonwealth to provide assistance to large employers and educational institutions (those with 250 or more employees or students), in the form of computer carpool matching processes and instructional literature. This regulation is based upon the comparable regulation for Boston and reflects the program now being planned by the Commonwealth. If a mandatory program is decided upon, additional regulations may be needed.

In connection with the traffic flow management plan for the Springfield Central Business District, the regulation would require the Governor or a designated State agency to develop a detailed implementation plan and schedule and submit it to EPA for approval. The regulation specifies several streets for one-way operation, additional streets to be closed to any traffic other than delivery or emergency vehicles, reduction or elimination of curb parking on specific streets, and prohibition of retail and wholesale deliveries in peak hours. In addition, the regulation would require that related traffic engineering planning and improvements be undertaken, such as traffic signal system adjustments. As a supplement to other measures, the regulation requires that a low-cost parking facility be developed in the space beneath the I-291 highway viaduct, on the fringe of the CBD, and that shuttle bus service be provided between that lot and the business area.

As for inspection and maintenance, it is assumed that regulations will be uniform for both the Boston and Springfield regions.

Also proposed is a regulation for monitoring the TCP as it is implemented, similar to a corresponding Boston regulation. The regulation would require the State to review and modify both air quality monitoring and traffic monitoring programs in order to provide the on-going information needed for evaluation of the effects of the TCP. In addition, a regulation is included that calls for implementing a plan for identifying and assessing potential carbon monoxide hot spots in the AQCR. Again, this regulation corresponds to a similar regulation for the Boston AQCR.

SOCIAL AND ECONOMIC IMPACTS

This report includes consideration of the social, economic, legal, and administrative impacts of the proposed transportation control measures. Each measure was separately analyzed. As a result of the total TCP, both positive and negative social and economic impacts on the region can be expected, with a substantial net positive benefit due largely to reductions in general air pollution-related costs and in automobile use costs to commuters.

Direct reductions in travel volumes are modest, and will depend upon the degree of carpooling that is achieved. The maximum reduction would be less than 3 percent of total vehicle-miles of travel in the region as a whole. These reductions, induced by the voluntary carpooling program and the improved transit service, will actually be somewhat more significant in certain areas because the reductions will occur largely in the densely populated portions of the AQSA, particularly, in and near Springfield. Concomitant reductions in gasoline consumption and related vehicle operating costs would result from the reduced vehicular travel.

The Springfield traffic flow management measures, while not intended as VMT-reduction measures, are expected to reduce congestion and delay and increase travel speeds, which will reduce fuel consumption and travel time for those travelling in downtown Springfield.

Transit improvements may be expected to produce significant social benefits in the form of increased mobility, especially for the young, old, or economically disadvantaged. These benefits are difficult to quantify, but add to the positive direct benefits of reductions in fuel consumption and vehicle expenses. Each commuter attracted to the proposed additional transit service would typically save $282 per year in repair, maintenance, and fuel costs, easily offsetting the transit fares for a net savings of $100 per year.

The inspection and maintenance program would produce substantial economic effects. With an annual inspection requirement, the inspection fees would be $1.3 million per year, and repairs would cost an estimated $3.12 million. These costs would be more than offset by an estimated savings of $5.46 million for gasoline (improved engine operation would increase fuel economy).

Various capital and operating costs would be incurred for the proposed measures. Stationary source controls are discussed in greater detail in Volume II. Transit improvements would involve both capital and operating costs and are discussed in the text, but such costs are not a result of the TCP because the transit program is being implemented separately. Traffic flow improvements will involve capital costs estimated to be $147,000, and will require certain operating costs as well. The capital and operating costs of the inspection-maintenance facilities were included in the inspection fees, discussed earlier.

SECTION II

INTRODUCTION

BACKGROUND

This document presents technical discussion and analyses relative to the proposed Transportation Control Plan for the Massachusetts portion of the Hartford-New Haven-Springfield Interstate Air Quality Control Region. The Transportation Control Plan sets forth those control measures that are required beyond the Federal Motor Vehicle Emission Control Program in order to meet the primary national ambient air quality standards for both carbon monoxide and oxidants.

The necessity for such a plan (with regard to carbon monoxide only) was formalized on May 31, 1972. On that date the EPA Administrator, in approving state implementation plans, advised the Governor of Massachusetts that in order to complete the requirements of the Clean Air Act[1] and of the pertinent EPA regulations,[2] a transportation and land use control plan for the Massachusetts portion of the Hartford-New Haven-Springfield Interstate Air Quality Control Region was to be submitted to the Administrator by February 15, 1973. Because no state had experience with such control measures, the Administrator, in setting the new date for submission of such plans, also extended the deadline for meeting the air quality standards from 1975 to 1977.[3]

On January 31, 1973, the United States Court of Appeals for the District of Columbia Circuit found that the Administrator did not conform to the strict requirements of the Clean Air Act of 1970 in permitting the several states to delay submission of transportation control portions of their implementation plans until February 15, 1973, and in granting them extensions until mid-1977 for attainment of the national primary ambient air standard without following the procedures established in the Clean Air Act.[4] Accordingly, the court ordered that the Administrator rescind the extension granted the states for implementation plans. The affected states were required to submit a control plan by April 15, 1973. For the Massachusetts portion of the Air Quality Control Region (AQCR), the plan was to show attainment of the national ambient air quality standard for carbon monoxide in downtown Springfield as expeditiously as possible, but no later than May 31, 1975.[5]

Because the Commonwealth of Massachusetts did not submit a plan by April 15, GCA/Technology Division, under an Environmental Protection Agency contract, prepared a Transportation Control Plan for Springfield, which was promulgated by the Administrator of EPA.[6]

Subsequent to the promulgation of the Transportation Control Plan, it was determined, through additional monitoring, that the standard for photochemical oxidant concentrations was also being exceeded in the Massachusetts portion of the AQCR. In light of this, the Governor of the Commonwealth was notified by letter[7] through the Region I Administrator, that a plan would have to be developed to reduce photochemical oxidant concentrations accordingly. The dates mandated for attainment of the national standards for carbon monoxide and photochemical oxidant concentrations were August 1, 1976,[8] and May 31, 1975, respectively.

Since the development of the Transportation Control Plan for downtown Springfield, air quality monitoring programs within the AQCR have become more extensive resulting in a clearer indication of both the carbon monoxide and oxidant problems. Because of the availability of additional data it was decided to review the promulgated Transportation Control Plan for downtown Springfield concurrently with the development of the control plan for photochemical oxidants.

SCOPE OF STUDY

The purpose of this report is to develop and evaluate transportation control strategies, including both the review of the previously-proposed plan for control of CO and development of strategies to effect reductions in photochemical oxidant concentrations. In preparing this report, the existing Transportation Control Plan (TCP) for Springfield was reviewed, along with the newly available data on ambient concentrations of photochemical oxidants. Several alternative transportation control measures were evaluated by GCA and submitted to EPA (Region I). After EPA review, the strategies and GCA's analyses were reviewed with the State and with the City of Springfield. Comments from EPA, the State, and the city have been considered by GCA in preparation of the plan recommended here.

An adjunct to the study reported in this volume has been an inventory and analysis of stationary hydrocarbon emission sources in the Massachusetts portion of the Air Quality Control Region, also performed by GCA, and reported in a companion volume. The study of stationary source emissions was utilized as a basis for determining the degree of additional emission reduction required from mobile sources after stationary source controls had been accounted for.

For the transportation control measures analyzed in this report, major implementation obstacles were noted and discussed with the various agencies responsible for the implementation of the controls, and after the probable air quality impact of the several controls had been determined. In connection with the documentation of the implementation obstacles, social and economic analyses were carried out for each transportation control measure. Finally, a surveillance review procedure was developed for monitoring implementation progress and the actual air quality impact of the transportation control strategies. It is anticipated that these procedures will be used for future periodic revisions to the Transportation Control Plan.

This study relied upon the best data and techniques available during the period of the study; moreover, certain assumptions were made regarding future events. The air quality predictions were based on the existing air quality measurements and on the accompanying emissions inventory; the baseline year was determined by the reported air quality data. The air quality predictions were also based on predicted automobile traffic patterns and predicted stationary source emissions, estimated by the application of expected growth rates. The predicted emissions were, in turn, based on anticipated emission control techniques and growth patterns and on the assumed outcomes of currently unresolved legal and political decisions. The discussions of social and economic impacts of the transportation control measures are based on existing and predicted economic, sociological, institutional, and legal considerations. Finally, the surveillance procedure presented in this report, although showing key checkpoints along the way toward implementation of the proposed controls, is itself dependent upon the same assumed pattern of future events.

It is clear, therefore, that the conclusions and recommendations of this report should not be construed as a program that must be rigidly followed, but rather as a framework upon which an optimum on-going program can be built as new data and techniques become available, as legal and political decisions are made, and as the assumptions regarding future events are validated or altered.

DEFINITION OF AIR QUALITY STUDY AREAS

The study reported here is related to the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region. The Massachusetts portion, hereafter referred to as the Air Quality Study Area or AQSA, consists of Franklin, Hampshire, and Hampden Counties, and is also referred to (by the Commonwealth of Massachusetts) as the Pioneer Valley Air Pollution Control District. Hydrocarbon control strategies are applicable to the entire Massachusetts portion of the AQCR.

For the carbon monoxide control strategies, analysis focused on the area in and around the Springfield Central Business District, which is where the carbon monoxide problem is expected to be most severe.

Figure II-1 shows the boundaries of the Massachusetts portion of the AQCR (the AQSA), and the City of Springfield. Further definition of the study area for carbon monoxide analysis will be found in Section IV. A complete list of the municipalities in the Air Quality Study Area is in Appendix A.

CONTENT OF THIS REPORT

Section III of this report describes and assesses the present air pollution situation in the air quality study area. As noted earlier, discussion is limited here to carbon monoxide and oxidants. Section III includes discussions of the methods used for assessment of air quality and emissions; natural features and meteorology; present air quality; present emissions; and methods for estimation of future emissions and air quality.

Section IV presents a detailed discussion of the transportation control measures reviewed in this report. Each control measure is discussed individually. For each measure there is a detailed description and explanation for its selection, followed by a discussion of its effectiveness as a pollution-control measure, its social impacts, and its economic impacts. Legal and administrative aspects are also discussed, along with a summary of the assumptions used for estimating effects. Discussion includes all the alternatives reviewed for this plan.

Section V presents an analysis of the effects of implementing all of the proposed transportation control measures. Whereas Section IV discussed each measure individually, Section V treats the recommended measures collectively, as a "package," thus taking into account their interaction. Discussion includes the direct impacts on transportation and air pollution and also the social and economic effects.

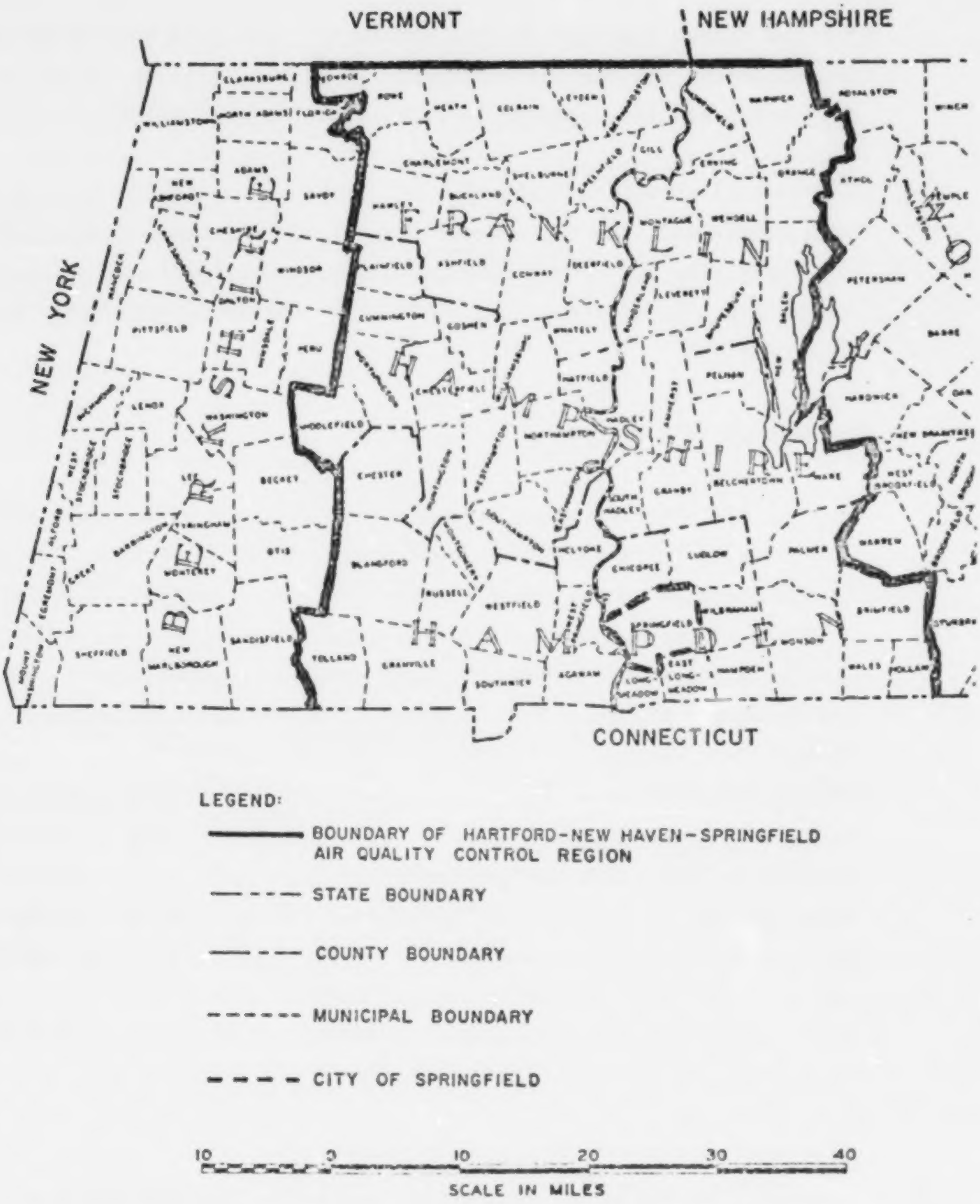
VERMONT
NEW HAMPSHIRE
NEW YORK
CONNECTICUT
FRANKLIN
BERKSHIRE
HAMPSHIRE
HAMPDEN
LEGEND:
BOUNDARY OF HARTFORD-NEW HAVEN-SPRINGFIELD AIR QUALITY CONTROL REGION
STATE BOUNDARY
COUNTY BOUNDARY
MUNICIPAL BOUNDARY
CITY OF SPRINGFIELD
10
0
10
20
30
40
SCALE IN MILES

Figure II-1. Air quality study area

Section VI presents the surveillance review process that will enable monitoring the progress of the plan's implementation as well as measuring the actual impact of the various strategies on air quality. In addition, important checkpoints are provided on a "milestone" chart indicating the critical actions, such as legislation or financing, that must be taken in order to implement the strategies.

Following Section VI are several appendices containing background information, detailed data, details of certain analyses discussed in the text and the proposed regulations for implementing the recommended plan.

REFERENCES

1. USC 1857 et seq, Clean Air Act.
2. 40 CFR 51.11(b) and 51.14, U.S. Environmental Protection Agency.
3. 37 FR 10842, U.S. Environmental Agency, Fed Regist, 37:10842, May 31, 1972.
4. USC 42 1857(c) 5(e), Clean Air Act, Sec 110(e).
5. 38 FR 7327, U.S. Environmental Protection Agency, March 20, 1973.
6. 38 FR 30827, U.S. Environmental Protection Agency, November 7, 1973.
7. U.S. Environmental Protection Agency. Letter to Governor of Massachusetts From Region I Administrator. February 14, 1974.
8. 38 FR 30964, U.S. Environmental Protection Agency, November 8, 1973.

SECTION III

VERIFICATION AND ASSESSMENT OF THE AIR POLLUTION PROBLEM

OUTLINE OF METHODOLOGY

General Procedures

The basic procedure used in the analysis of air quality for this report was to develop estimates of the pollutant concentrations that could be expected in the Air Quality Study Area in 1976 with no transportation control measures applied (the "no-strategy" case). Pollutant concentrations were determined by two procedures. The first method, used for carbon monoxide (CO), involved the use of a computer model to simulate various meteorological and emissions data characteristics and relate these to resulting pollutant concentrations. In the second method, for oxidants (Ox), pollutant concentrations were determined by a procedure that assumes that there is a fixed ratio between emissions and pollutant concentrations; this is referred to as the e/c ratio and implies that pollutant concentrations are proportional to emissions of pollutants. Pollutant concentrations were determined by the application of the e/c, using non-vehicular emissions data derived from a stationary source inventory (Volume II). Vehicular emissions for both methods were computed by the revised computer program called VEHEMI13. These computer-based calculations were, in turn, based on a traffic study performed expressly for the development of this plan and data obtained from the Massachusetts Department of Public Works. For both methods, comparison of the "no-strategy" case with the appropriate ambient air quality standard determined the allowable or "safe" rate of emissions. This, in turn, formed the basis for the assessment and technical evaluation of the transportation and stationary source control strategies presented in this plan.

Emissions from non-vehicular sources were obtained from a Hydrocarbon Emission Inventory performed by GCA/Technology Division (see Volume II). Emissions from vehicular sources were computed following the recommendations given in EPA publications.[1,2,3] A draft copy of Supplement No. 5[4,5] to AP-42 has recently been made available and was used for this report. That document contains several major changes in the methodology used in computing vehicular emissions; however, the basic approach as developed in the original work by Kircher and Armstrong remains essentially valid.

Air quality data from each sampling device within the AQCR were reviewed and evaluated and data tentatively selected as being representative of the second-highest concentration of oxidants and carbon monoxide to be expected within the area were submitted to EPA for their review and concurrence. A questionnaire (see Appendix B) was prepared and submitted to the Pioneer Valley Air Pollution Control District to obtain data on the various air quality monitoring locations, types of instruments, extent and quality of maintenance, and any problems noted by the operating personnel. Meteorological records were examined and parameters of significance in air pollution were compared for periods of high reported concentrations. Seasonal and diurnal variations in pollutant concentrations were also noted. Finally, the pollutant concentrations that would form the basis for the required emissions reductions were decided upon in concert with the representatives of the State and EPA.

Methodology for Carbon Monoxide

Because ambient concentrations of carbon monoxide (CO) at any given location are highly dependent upon CO emissions in the immediate vicinity, it is entirely reasonable to conclude that analyses of CO problems should focus on very localized areas such as separate intersections, or highway sections, rather than on larger areas such as a central business district, an entire city or town, or AQCR. This becomes more evident when one considers the primary source of CO-vehicular traffic - and the degree of variation in its distribution throughout an area. Even in very small areas such as the Springfield central business district, there is very little uniformity on the street system with regard to traffic volumes and operating speeds, two of the most critical factors in CO emissions. The strong localization tendency of CO concentrations can be seen in Figures III-1 and III-2. These figures show average and maximum 1-hour average concentrations of CO by time of day for two monitoring stations within downtown Springfield. The two stations are located about 1400 feet apart, but, as indicated by the two figures, CO concentrations are quite different at the two locations for corresponding time periods. The significance of this is that CO concentrations are a highly localized phenomenon varying significantly throughout even very small areas.

It was indicated that a primary reason for this need to study individual locations when analyzing CO problems is that the source characteristics - i.e., traffic density and speed - are highly non-uniform throughout an area. A second consideration involves the effects of micrometeorological and topographical characteristics. These factors, also, are not necessarily uniform over small areas, yet they have substantial impact on pollutant concentrations mainly because they directly affect the rate at which pollutants are dispersed from the location.

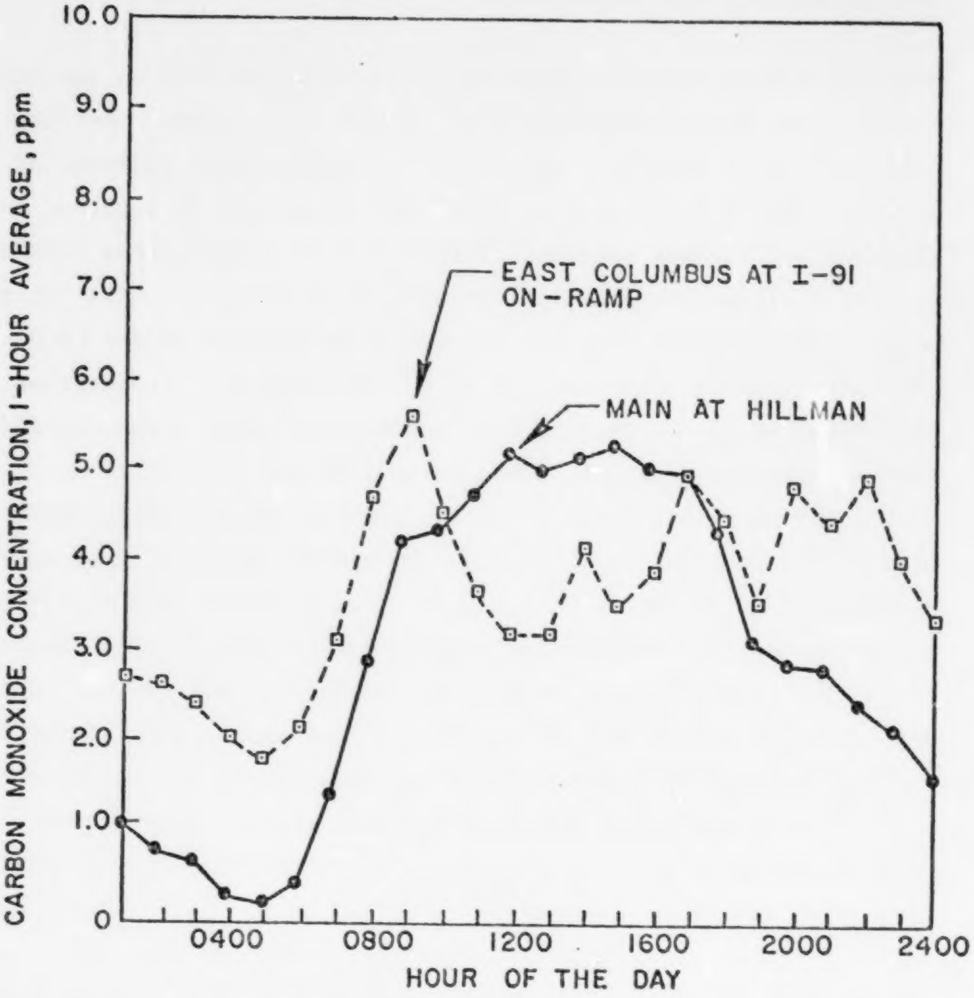

Figure III-1. Ambient concentration of carbon monoxide in Springfield, Massachusetts, during February 1974, showing the monthly average 1-hour average concentrations for each hour of the day at two sampling sites

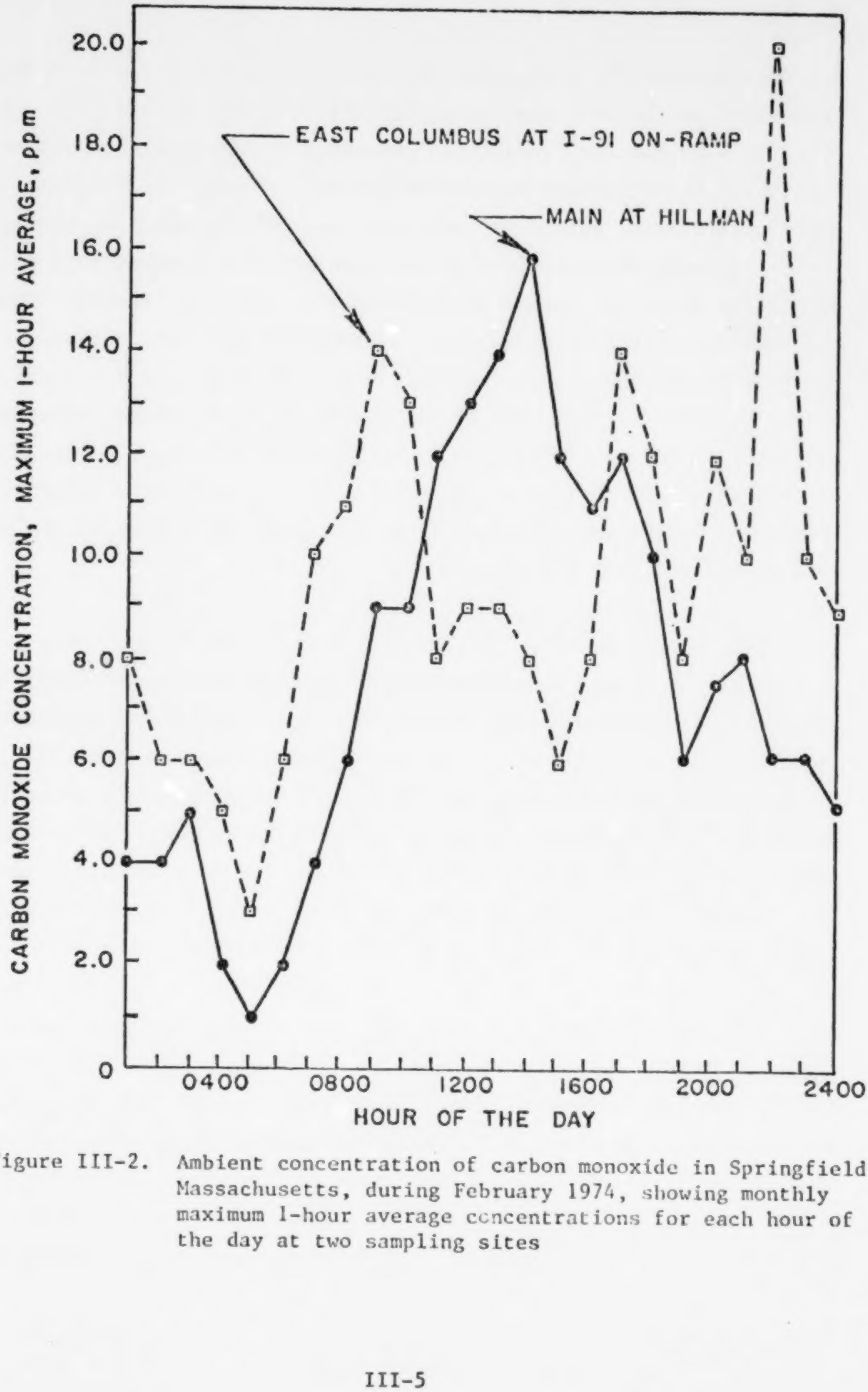

Figure III-2. Ambient concentration of carbon monoxide in Springfield, Massachusetts, during February 1974, showing monthly maximum 1-hour average concentrations for each hour of the day at two sampling sites

Previous methods for evaluating the extent of carbon monoxide problems were based on the idea that if a violation in the standard occurred anywhere in a particular "zone" then emissions within that entire zone would have to be reduced proportionally (the rollback technique). The major difficulties with this technique are: (1) it does not insure that concentrations everywhere within the zone would be reduced to a level of compliance since the calculated reduction is based on concentrations at one location only (the monitoring site) within the zone that may or may not be where maximum concentrations occur; (2) there are instances in which control strategies may be applied to locations where reductions might not be needed at all were it not for the fact that they happen to lie within a zone that also contained a location requiring control. Addressing individual locations greatly reduces the extent of the problems associated with the area or zone type of analysis.

CO evaluation was performed for the Springfield CBD (only). The general method used to evaluate carbon monoxide problems and their control was to utilize a specially designed mathematical model capable of accounting for variable such as local emissions, meteorology, spatial orientation, and background concentrations of the pollutant. This method is generally accepted as being capable of providing accurate estimates of concentrations. In this analysis of carbon monoxide, the APRAC-1A diffusion model was utilized. This model is discussed briefly in the following paragraphs and in greater detail in Appendix C of this report.

APRAC-1A Diffusion Model - As indicated previously, an important source of error in using a proportional model to estimate air quality has been the inability of the model to reflect variations in conditions throughout the analysis area. Further, in an urban environment, concentrations of carbon monoxide at street level have been shown to be directly affected by such factors as building height and spatial orientation, street orientation, and even the particular side of a street (windward versus leeward side).

The APRAC-1A model was designed specifically to simulate CO concentrations based on local meteorological and traffic data. Meteorological data inputs to the model include:

- Hourly surface wind speed, direction, and temperature, as well as extent of sky cover.
- Minimum and maximum surface temperature for each day.
- Upper air temperature for each day studied.

The surface wind speed and direction are used to determine the transport characteristics of the wind. Other factors, such as mixing depth and stability, are derived from the basic meteorological data. The importance of these data is that the rate of diffusion of carbon monoxide generated on the street system depends directly on the meteorological conditions described by the data.

Required traffic data consist primarily of two components - highway link data and emissions data. Highway link data describe the traffic volumes and speeds on the street system and the geometric arrangement of the streets. Traffic volume and speed data are provided for typical weekdays, Saturday, and Sunday or holiday characteristics.

Emission factors are used that reflect the emission characteristics of the particular vehicle-fleet that typically uses the street system. Emission factors depend upon the vehicle age and type (passenger cars, light trucks, heavy trucks, etc.).

The APRAC-1A model accounts for both the background concentrations of CO due to diffusion and the concentration of CO from vehicles within the immediate vicinity of the location being evaluated.

In using the APRAC-1A model a number of specific sites within an area are selected for analysis; these are referred to as receptor locations. In an area where air quality sampling sites exist, the locations of these sites are also included as receptor sites. By locating receptors in this fashion, the calculated concentration can be compared with measured data. Other receptor sites include locations that may experience high CO concentrations or that may undergo substantial changes in traffic volume or speed characteristics because of the implementation of various strategies. The APRAC-1A model indicates what the air quality at these receptors may be under varying conditions of traffic and meteorology.

Summary - Because carbon monoxide is a primary pollutant - i.e., it is generated directly from the source (mainly, the automobile tail pipe) - distribution of CO emissions is highly localized in both time and space. Fluctuations in ambient CO concentrations in cities are often coupled closely to traffic variations for periods of time as short as a few minutes to an hour. There is also in many cities a well-defined diurnal pattern in ambient CO concentrations, with pronounced peaks coinciding with morning and evening rush hour traffic. Figure III-1 illustrates this type of pattern. Therefore, any evaluation or assessment of a CO problem must be based, in part, on analysis of traffic and the emissions resulting therefrom. Equally as important in the analysis of specific locations are the meteorological characteristics of the area. A computer model (APRAC-1A) has been developed that utilizes data regarding an area's traffic and meteorological characteristics to predict resulting concentrations of CO on a local level. This model was used in the study reported here for the evaluation of carbon monoxide.

Methodology for Oxidants[6,7,8]

Unlike carbon monoxide, oxidants are best analyzed on an area-wide basis. The reason for this can best be understood by investigating the general nature of oxidants.

Formation of Oxidants - Photochemical oxidants occur as the result of a series of complex reactions between the ultraviolet component of sunlight, reactive organic substances (hydrocarbons) and oxides of nitrogen, to ultimately form oxidants such as ozone (O_3).[9,10] Much is yet to be learned regarding ozone formation through photochemical reactions, however, hydrocarbon emissions are to be the principal contributor to the formation of photochemical oxidants (smog).

Hydrocarbons can be categorized as either saturated or unsaturated. The distinction between these is that saturated hydrocarbons tend to be stable, therefore less susceptible to photochemical reaction and formation of oxidants.

Unsaturated hydrocarbons, on the other hand, are more susceptible to photochemical reaction. This general group consists of literally thousands of compounds with a wide range of potential reactivity. Adding to the complexity of the study of photochemical oxidant formation is the existence of synergistic effects. The reactivity of a number of hydrocarbons is influenced by such variables as the amount and intensity of available sunlight, the mix of other classes of hydrocarbons, etc. Also, reaction rate within a system may be controlled by the reactivity characteristics of a particular compound in that system.

The principal sources of reactive hydrocarbons entering the atmosphere include fossil fuel combustion, evaporation from storage facilities, and direct discharge by various industrial processes.

Meteorological variables also affect the formation of oxidants.[9,10] Ultraviolet light from sunlight is required for the photochemical reaction of nitrogen dioxide to form nitric oxide. The formation of oxidants is, therefore, affected by factors that affect the intensity of incoming solar radiation, such as altitude, the season of the year, or atmospheric turbidity. The rate of the chemical ractions varies directly as the ambient temperature; thus, factors that affect air temperature, such as the season or the time of day, also affect the rate of formation of oxidants. The concentrations of precursors (reactive hydrocarbons and oxides of nitrogen), and thus the rate of formation and the ultimate level of oxidants attained in a given region, are influenced by meteorological conditions - wind speed and direction, pressure systems, temperature inversions, and the mixing depth.

Hydrocarbons are also emitted to the atmosphere from natural sources. Although natural source hydrocarbon emissions can account for a major portion of total hydrocarbon emissions, only a very small fraction of these emissions are reactive. For this reason, natural source hydrocarbon emissions are not considered to be an important factor in the total problem of oxidants. Rather, natural source hydrocarbon emissions are considered to contribute to a rather low-level, but consistent, concentration of oxidants referred to as background concentrations.

Temporal and Spatial Characteristics - As outlined above, the formation of oxides is influenced by meteorological and other variables. It is to be expected, therefore, that the concentrations of the precursors and the products of reactions would show certain temporal and spatial patterns.[9,10,11,12,13]

In urban areas a well-marked weekday diurnal pattern of ozone and oxides of nitrogen has been observed for some years. Concentrations of these pollutants are low during the nighttime hours. Nitrogen oxides and hydrocarbons are emitted in large quantities by the morning rush-hour traffic. During the late morning, as the intensity of sunlight increases, nitrogen dioxide reacts with hydrocarbons, and ozone and other oxidants begin to accumulate. Peak ozone concentrations usually occur in most localities between 12 noon and 3:00 p.m., although the peak hourly concentrations are sometimes observed in the later afternoon, between 3:00 and 6:00 p.m.[12] Increasing atmospheric instability, decreased traffic volume, and the formation of the oxidants themselves all help to lower precursor concentrations during the afternoon. The evening rush hour traffic contributes more nitrogen oxides and hydrocarbons, but since the intensity of sunlight has then decreased, little additional ozone is formed. In fact, that which has already accumulated tends to be destroyed by the increased amounts of oxides of nitrogen. Finally, the ozone concentration returns to the low nighttime levels. Figure III-3 shows this diurnal pattern, using data for the Springfield area.

The diurnal patterns of oxidizing pollutants on weekends appear to be somewhat different from those observed during the work week.[10,11,13,14] Some studies have shown that ozone concentrations may sometimes be higher on weekends than they are through the week, even though the emissions of precursors are generally lower on weekends. This suggests that a reduction in emissions of precursors may not necessarily result in a proportional decrease in oxidant concentrations in the same time period and location; the effect may occur later and be greater or less than the decrease in emissions.

The concentration of oxidants also shows seasonal patterns, with the highest levels occurring from late spring to early fall when the rate of insulation is the highest and consequently the photochemical reaction rate is also at a maximum.[9,10,12]

Another aspect of the study of oxidant problems is the issue of transport of oxidants or their precursors from one geographic area to another. There is disagreement regarding the relative importance of the transport of hydrocarbons and oxidants. Some investigations (reviewed in Reference 6) have indicated that high concentrations of oxidants can be found in rural areas many miles from major hydrocarbon emission sources. Speculation is that these high concentrations may be attributed, in part, to transport either from the upper atmosphere or from upwind sources such as urban centers, etc.[15,16,17] Further, the possibility of transcontinental transport has been suggested and investigated. Transport of

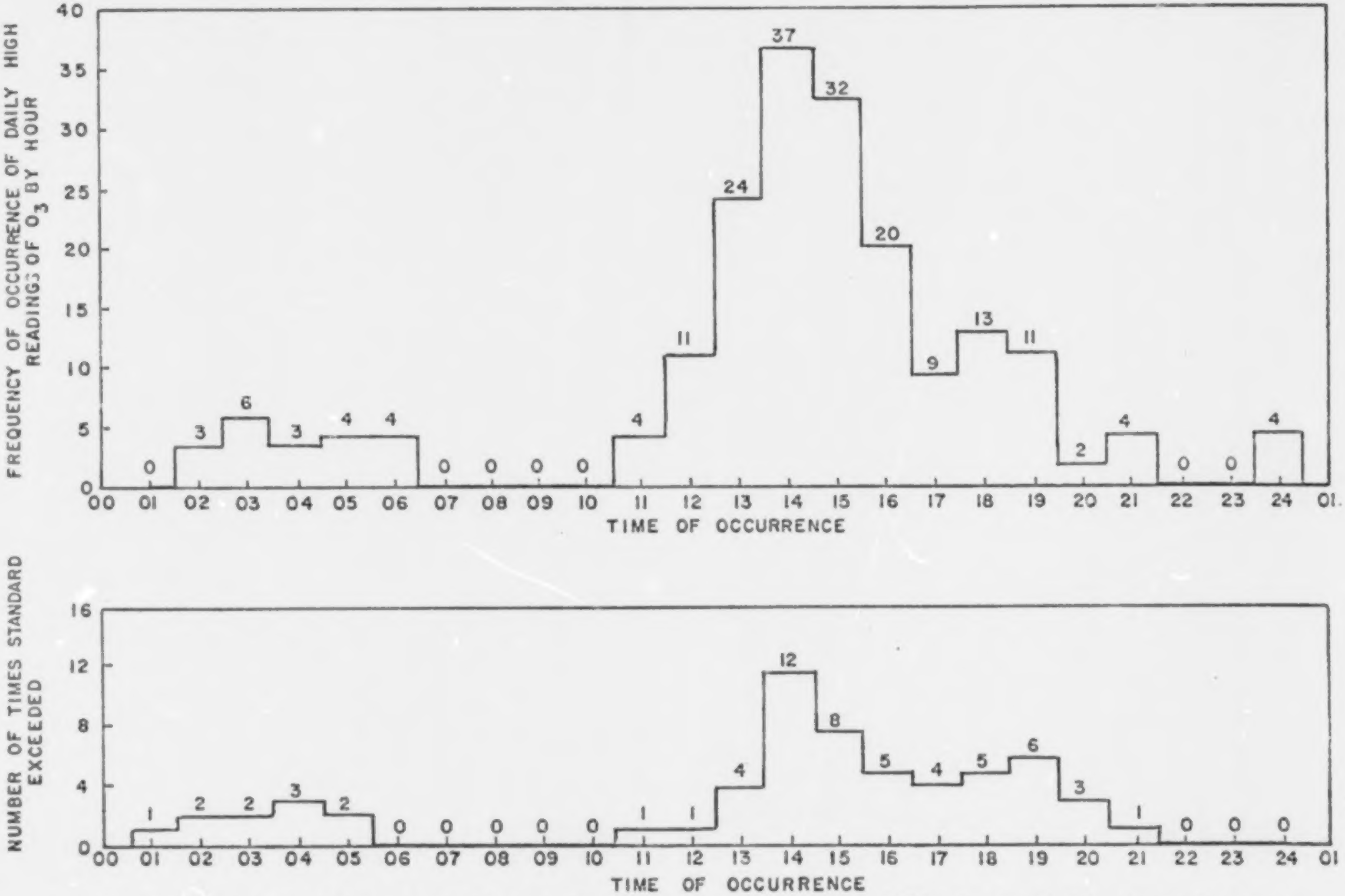

Figure III-3. Distribution of maximum ozone concentrations, 1973, Springfield, Massachusetts

oxidants is receiving attention and study and it appears that many of the tentative conclusions support the theory that regional transport is a significant contributor to the oxidant problems in many areas; by the same token, however, there is no implication that the importance of contributions by local sources is diminished.

Quantitative Relationships of Oxidants and Precursors — The appearance of oxidants in the urban atmosphere is dependent upon chemical reactions which are, in turn, dependent on variables such as sunlight, wind, and temperature, as well as on the extent and nature of atmospheric dilution and dispersion. Because of the many variables involved, and because of the complex nature of the photochemical reactions themselves, the relationship between precursor emissions and ambient concentrations of oxidants is indirect and nonlinear.[9] It appears that for a given rate of emission of hydrocarbons there exists an upper limit on the quality of oxidant that can be generated in the atmosphere.[18] The maximum oxidant concentration for a given rate of hydrocarbons emission is reached only infrequently. This is because the combination of atmospheric conditions giving rise to the maximum potential for the production of oxidants occurs only on about 1 percent of all days.

Methodology Defined — The current state-of-the-art regarding evaluation and analysis of oxidants problems requires that certain assumptions be made which tend to limit the accuracy of the evaluation. The most basic assumption made is that reduction of the total emissions of precursors within an area will result in a similar (proportional) reduction in pollutant concentrations within that same area. The technique, then, for evaluating oxidant problems is the Proportional Rollback, as described in the following paragraphs.

Linear rollback - The linear rollback technique assumes that the concentration of a pollutant is equal to the background concentration of that pollutant plus some linear function of the emission rate of the pollutant, or:

$$c_t = c_b + k\ e$$

where c_t is the total concentration of the pollutant

c_b is the background concentration of the pollutant resulting from natural sources

e is the total emissions of the pollutant for a particular averaging period, typically 24 hours

k is a constant

Generally c_b is a very small fraction of c_t and is often neglected. The total emissions, e, can be calculated or derived from inventories of emissions. Therefore, in an area where the concentration of a pollutant is monitored, the only unknown is the value of k. Because all other elements of the equation are known, it is a simple matter to calculate k. The equation in its most common form is expressed as $e/c = r$, where r is referred to as the e/c ratio; its value is $\frac{1}{k}$.

In determining the reduction in emissions required in a particular area in order to meet National Ambient Air Quality Standards (NAAQS), the second highest validated concentration ever recorded is used with the contemporary emissions to determine the corresponding r value. The allowable emissions are then determined as follows:

$$e_a = c_s \cdot r$$

where e_a is the allowable or safe emission rate

c_s is the National Air Quality Standard for the pollutant (in this case, for ozone, $c_s = 0.08$ ppm)

r is a constant

The emissions reduction required, then, is equal to the difference between the baseline emissions and the calculated allowable emissions or, expressed as a percent reduction:

$$\%\text{ reduction required} = \frac{(\text{baseline emissions}) - (\text{allowable emissions})}{\text{baseline emissions}} \times 100$$

The chief advantages of the proportional rollback model are that it is relatively simple and straightforward to use, and its theoretical basis is readily understood. While the technique does have various limitations, these are judged to be not so severe as to preclude its use in developing Transportation Control Plans. The most important limitations of the model include its insensitivity both to spatial resolution with regard to the source-receptor relationship, and to local variations in meteorology and topography that occur within a region.

Various efforts are underway to refine the process of analyzing oxidant problems by utilizing more sophisticated models, but at the present time these remain in the experimental stage and therefore not suited for use in the development of a Transportation Control Plan.

As mentioned previously, the nature of oxidants requires that large areas be considered in the analysis of oxidant problems. The exact area used in an analysis is largely a matter of judgment and the determining factor is often the manner in which supporting data are organized; whether by state, county, planning region, etc. It is often found that, while these units are not in any sense associated with natural air sheds, the convenience of obtaining and processing the considerable amounts of data required for analysis may offset the possible losses in definition of the problem. In developing the Transportation Control Plan for the Springfield area, the entire Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region has been used as the study area.

Summary - The nature of oxidants requires that the approach to its analysis be quite different from that used for carbon monoxide analyses. The technique employed is to study the emissions of precursors (reactive hydrocarbons and oxides of nitrogen) for very large areas and, employing a proportional rollback model, to determine the emissions reduction required in that area. While this approach has several important limitations, it is judged appropriate in light of the fact that more sophisticated and responsive techniques are not available.

NATURAL FEATURES AND METEOROLOGY

Natural Features

This portion of Section III discusses topography and climatology in the study area.

General - As explained in Section II and Appendix A, the study area for this report consists of Franklin, Hampshire, and Hampden Counties. The relationship of this area to the rest of Massachusetts is shown by Figure III-4.

The total population of the three-county area, based on the 1970 U.S. Census, is approximately 650,000 people, distributed throughout a land area of about 1910 square miles. The most densely populated and developed portion of the AQCR is within an area defined as the Springfield-Chicopee-Holyoke Standard Metropolitan Statistical Area (SMSA) as shown by Figure III-5. The population within this 506 square-mile area is about 525,000. To the north, east, and west of the SMSA, land-use and population densities generally decrease rapidly, while to the south, land-use and population characteristics change only slightly. The Hartford, Connecticut, SMSA is contiguous from the southern boundary of the Springfield-Chicopee-Holyoke SMSA.

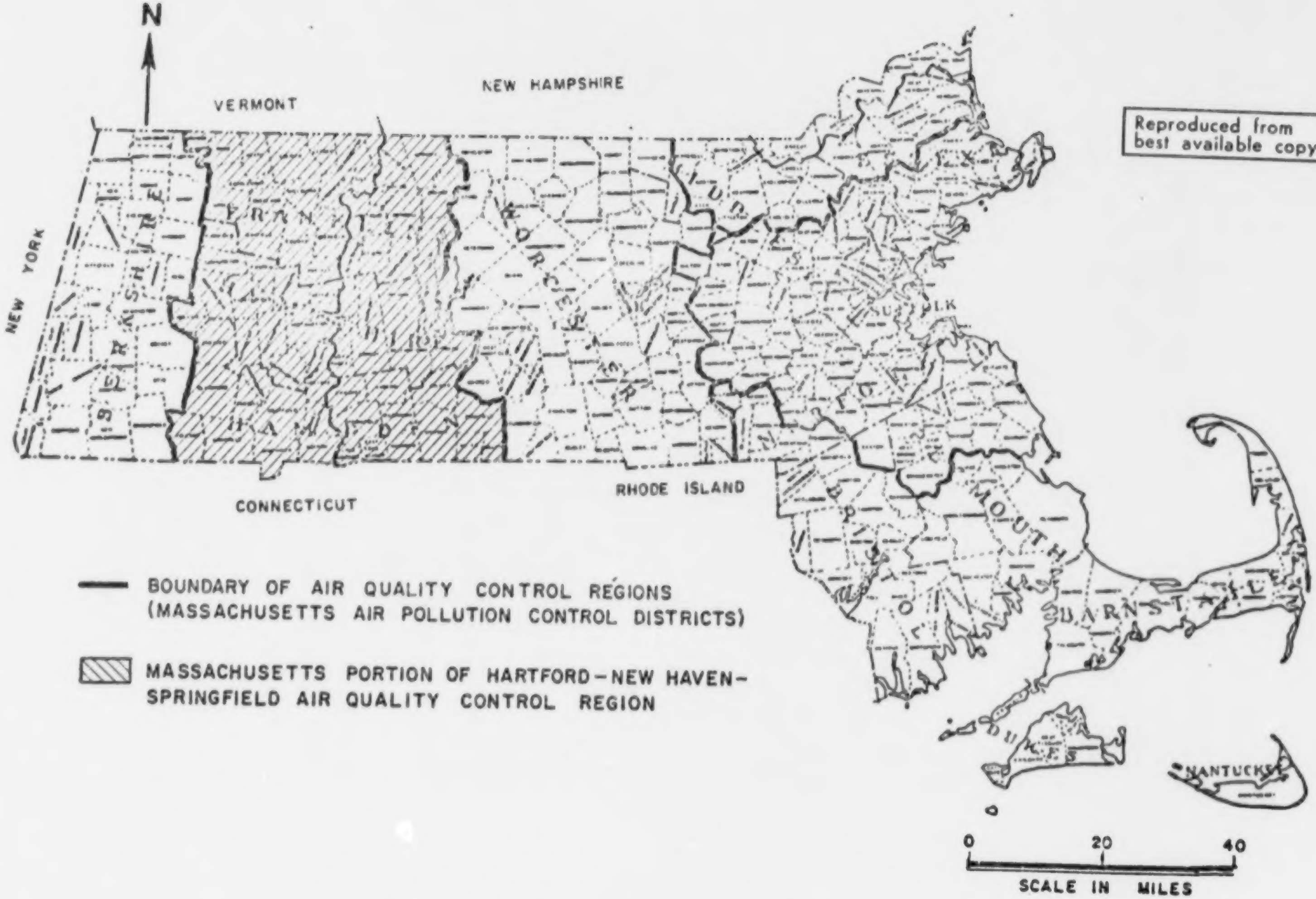
N
VERMONT
NEW HAMPSHIRE
NEW YORK
CONNECTICUT
RHODE ISLAND
WORCESTER
DUKES
BOUNDARY OF AIR QUALITY CONTROL REGIONS (MASSACHUSETTS AIR POLLUTION CONTROL DISTRICTS)
MASSACHUSETTS PORTION OF HARTFORD-NEW HAVEN-SPRINGFIELD AIR QUALITY CONTROL REGION
0
20
40
SCALE IN MILES

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Figure III-4. AQCR's in Massachusetts

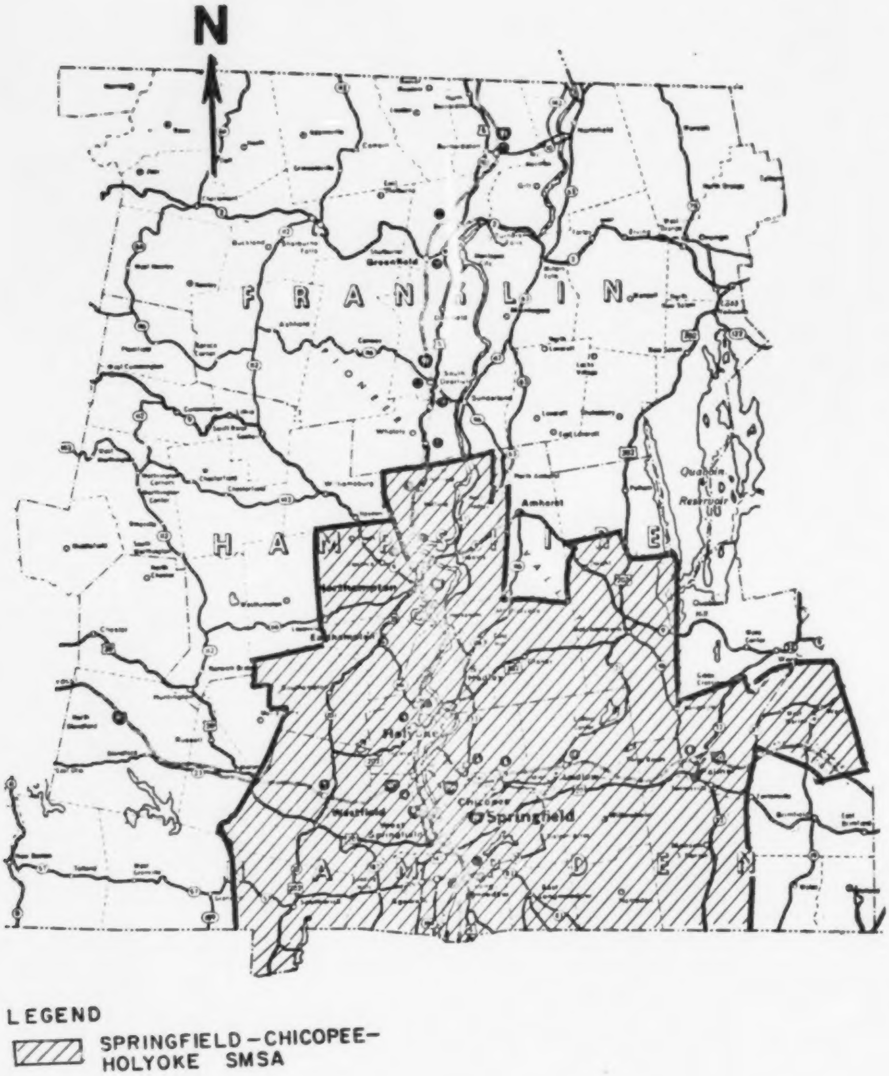

N
FRANKLIN
Greenfield
Amherst
Quabbin Reservoir
HAMPSHIRE
Northampton
Holyoke
Westfield
West Springfield
Chicopee
Springfield
HAMPDEN
LEGEND
SPRINGFIELD-CHICOPEE-HOLYOKE SMSA

Figure III-5. Springfield-Chicopee-Holyoke Standard Metropolitan Statistical Area

The AQCR's northern portion, consisting mainly of Franklin County, is essentially rural in nature. The Towns of Orange and Greenfield are the focal points of industrial and economic activity within this County.

The most dense motor vehicle usage occurs within the SMSA and along the Interstate Highway System (I-91 north and south generally along the Connecticut River, and I-90 east and west through Hampden County).

Topography - The central portion of the AQCR comprises the Connecticut River Valley lowlands. These lowlands are flanked by hilly and mountainous terrain with elevations ranging from about 100 feet to over 1000 feet above sea level. This valley extends the length of the AQCR with a north-south orientation. The western boundary of the region is delineated by the Berkshire Mountains, while to the east, rolling, hilly terrain prevails. Although not an entrapped geographical region, there is definitely a north-south channeling along the river valley. The most densely populated areas of the AQCR are within the Connecticut River Valley.

General Climatology - The meteorology of the AQCR is typical of the meteorology of New England. It is characterized by rapid progressions of various weather systems moving generally in an easterly direction across the region. The resulting unstable weather conditions are quite conductive to the rapid dispersion and transport of pollutants generated within the area. New England in general is relatively free from the occurrence of stagnant weather systems and their associated prolonged pollution episodes.

While the meteorological conditions of the region are generally favorable for dispersion of pollutants, certain aspects of that meteorology tend to result in brief periods of atmospheric stability and stagnation. It is during these periods that the potential is the greatest for air quality problems to occur within the AQCR. The following paragraphs discuss in more detail the meteorological conditions most closely associated with air pollution episodes.

Air Pollution Meteorology - Air Pollution Climatology[19]

Meteorological parameters that contribute to high air pollution potential over the region include stable atmospheric conditions, low wind speed, and to some extent adverse wind direction. These parameters are usually associated with stagnating anticyclones which, fortunately, are not common occurrences over New England.

Weather phenomena occurring in western Massachusetts that are associated with high potential for pollution episodes involve two fundamentally different types of meteorological situations. The first is characterized by the existence of a high pressure ridge west of the region. Generally, this condition results in light west through north surface winds in western Massachusetts. This condition is unfavorable for dispersion of pollutants since it can have a stablizing effect on the atmosphere that is associated with the formation of subsidence inversion caused by the warming aloft from the descending motion of the upper air.

The second general condition involves the approach of a warm front to the New England area. The associated warm air currents will override the cooler air already established over the region resulting in the formation of a frontal inversion.

A third type of situation that may occur within the region is the formation of temperature inversions due to nocturnal radiation. On clear nights when winds are relatively calm, the earth radiates heat to space. As the ground cools, the layer of air next to the ground also cools but at a more rapid rate than does the air mass aloft. The result of a layer of relatively cold air existing between the ground and the warmer air aloft is a radiation inversion.

Meteorological Factors in Air Quality Modeling[6,8,19] - Given the above analysis of general weather characteristics associated with high pollution probability it is obvious that any attempt to predict pollutant concentrations must include meteorological factors. The following paragraphs discuss these factors.

Mixing depth - The mixing depth is defined as the thickness of the surface layer in the lower atmosphere within which air pollutants can be vigorously mixed by natural turbulence in that layer.

For the AQCR the annual average afternoon mixing depth is 1300 meters. The seasonal average varies from 1000 meters in winter afternoons, to 1400 meters in spring and summer afternoons. Wind speeds through the mixing layer vary from 8.8 meters per second in spring afternoons to 5.0 meters per second during the summer. The annual average afternoon wind speed through the mixing layer is approximately 8.0 meters per second.

Stability data - Stability refers to the mixing potential of an air mass through natural turbulence. This potential is directly related to the vertical temperature profile of the air mass.

Stability roses for each stability class covering a 5-year period are shown in Appendix D. The data therein were developed from observations at Westover Air Force Base in Chicopee Falls, Massachusetts. The channelizing effect of the Connecticut River Valley on the wind can be seen from the wind roses - the predominant wind direction having a strong north-south component.

Data sources - The major sources of meteorological and climatological data are the Westover Air Force Base weather station, Chicopee Falls, Massachusetts ; and National Weather Service stations at Bradley International Airport, Windsor Locks, Connecticut; and the Albany Airport, Albany, New York. Also, summaries of past data for these stations are available from the National Climatic Center, Asheville, North Carolina.

AIR QUALITY

Classification of the Regions

The resources expended in developing implementation plans for any air quality control region should be commensurate with the degree and complexity of the air pollution problem. Consequently, a classification system was developed by the Environmental Protection Agency that categorized each AQCR in terms of priorities. Tentative classifications were based on measured or estimated air quality and population, and finalized after consultation with state agencies. The classification (priority I, II, or III) defines the implementation plan requirements for that AQCR. Priority I regions are the most heavily polluted, with levels well above the national standards; priority III regions are the least polluted, with levels near or below standards.

The classification applies to the entire AQCR whether intrastate or interstate; thus, the classification established in the "worst" state applies to those areas of each state included in an interstate AQCR.

The interpretation of these classifications and the general plan requirements defined by the various priorities can be found in the EPA regulations published in the Federal Register.

The classifications established for the Hartford-New Haven-Springfield Air Quality Control Region is shown in Table III-1.

Table III-1. CLASSIFICATION OF THE HARTFORD-NEW HAVEN-SPRINGFIELD AQCR

Region	Priority				
	Set I pollutants		Set II pollutants		
	Particulates	SO_2	NO_2	CO	Oxidants
Hartford-New Haven-Springfield	I	I	III	I	I

Instrumentation

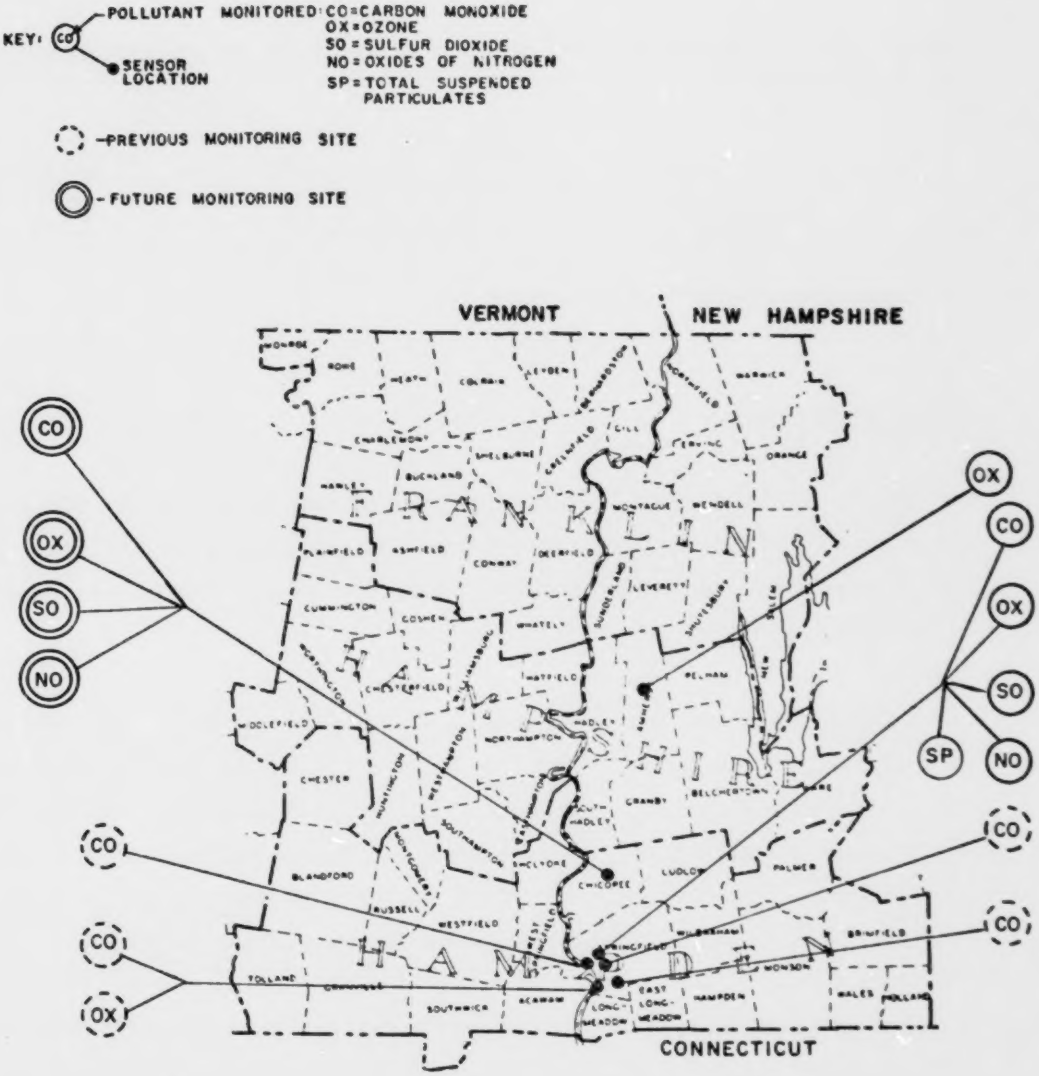
General - A questionnaire (See Appendix B) was developed by GCA for the purpose of obtaining specific information pertaining to the state of the instrumentation and other components of the Massachusetts air quality monitoring network.

Currently there are two monitoring sites in operation in the Region. The first, located in Amherst, monitors Ozone only while the second, located in downtown Springfield, monitors ozone, carbon monoxide, sulfur dioxide, and oxides of nitrogen. Four other sites have been used to monitor carbon monoxide; the location of these past and present sites as well as a planned additional site, are shown by Figures III-6 and III-7.

Specific - The following paragraphs discuss in some detail, the instrumentation at each location as well as other pertinent information regarding operation of the site.

Springfield - All sites in Springfield are or were located within the downtown area. The locations are discussed by site number (See Figure III-7).

Location 1 – This station, located at the intersection of Main and Hillman Streets in downtown Springfield, monitored carbon monoxide concentrations from July 24, 1973, through June 10, 1974, when instrument


KEY:
CO
POLLUTANT MONITORED: CO = CARBON MONOXIDE
OX = OZONE
SO = SULFUR DIOXIDE
NO = OXIDES OF NITROGEN
SP = TOTAL SUSPENDED PARTICULATES
SENSOR LOCATION
-PREVIOUS MONITORING SITE
-FUTURE MONITORING SITE
VERMONT
NEW HAMPSHIRE
CONNECTICUT
FRANKLIN
HAMPSHIRE
HAMPDEN
CO
OX
SO
NO
OX
CO
OX
SO
SP
NO
CO
CO
CO
OX
CO
MONROE
ROWE
HEATH
COLRAIN
LEYDEN
NORTHFIELD
WARWICK
CHARLEMONT
GREENFIELD
GILL
ERVING
ORANGE
BUCKLAND
SHELBURNE
HAWLEY
MONTAGUE
WENDELL
PLAINFIELD
ASHFIELD
CONWAY
DEERFIELD
LEVERETT
SHUTESBURY
CUMMINGTON
GOSHEN
WHATELY
SUNDERLAND
HATFIELD
PELHAM
CHESTERFIELD
MIDDLEFIELD
NORTHAMPTON
HADLEY
AMHERST
CHESTER
HUNTINGTON
SOUTH HADLEY
GRANBY
BELCHERTOWN
SOUTHAMPTON
HOLYOKE
BLANDFORD
CHICOPEE
LUDLOW
PALMER
RUSSELL
WESTFIELD
WEST SPRINGFIELD
SPRINGFIELD
WILBRAHAM
BRIMFIELD
TOLLAND
SOUTHWICK
AGAWAM
LONGMEADOW
EAST LONGMEADOW
HAMPDEN
MONSON
WALES
HOLLAND

MASSACHUSETTS PORTION OF THE HARTFORD-NEW HAVEN-SPRINGFIELD AQCR

Figure III-6. Ambient air quality monitoring sites, regional view

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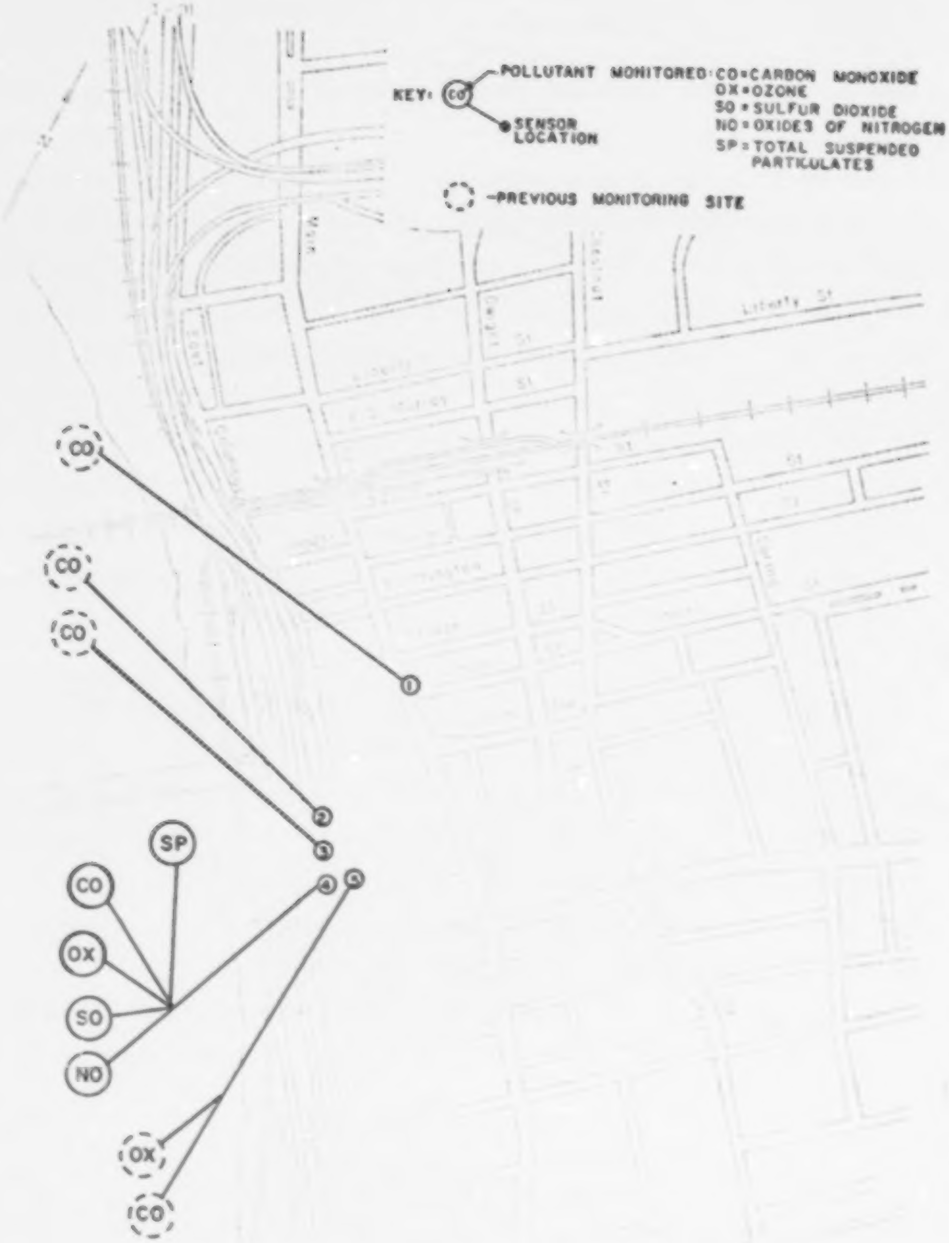
KEY: CO -POLLUTANT MONITORED: CO = CARBON MONOXIDE
OX = OZONE
SO = SULFUR DIOXIDE
NO = OXIDES OF NITROGEN
SP = TOTAL SUSPENDED PARTICULATES
SENSOR LOCATION
-PREVIOUS MONITORING SITE
Main
Dwight
Chestnut
Liberty St
CO
CO
CO
SP
CO
OX
SO
NO
OX
CO
1
2
3
4
5

Figure III-7. Ambient air quality monitoring sites, Springfield

problems made it necessary to cease operations. The instrumentation used included an MSA Lira 200 nondispersive infrared device, manufactured in 1971, for carbon monoxide. This instrument was located in the second story of a five-story building on the northerly corner of the intersection. The probe was located approximately 20 feet above the street pavement and 4 feet out from the side of the building. Main Street, in the vicinity of the site, carries very high traffic volumes at low speeds with many interruptions occurring to flow caused by pedestrian activity as well as by conflicting traffic movements nearby. The highest levels of carbon monoxide recorded in the AQCR were recorded at this station. Carbon monoxide concentrations recorded at this station were utilized as baseline data in the air-quality modeling analysis of downtown Springfield.

Location 2 - This station, located on East Columbus Avenue, monitored carbon monoxide concentrations from December 12, 1970 to October 31, 1972. The instrument used here was an Intertech, nondispersive infrared device, manufactured in 1970. This instrument was located on the roof of a powerhouse building on the west side of East Columbus Avenue, north of Court Street. The probe was located about 15 feet above the pavement and about 10 feet from the edge of East Columbus Avenue. East Columbus Avenue carries high volumes of traffic at moderate speeds. Interstate 91 is located about 100 feet from this site. The site was somewhat confined by surrounding buildings.

Location 3 - This station was located in the basement of a building on Court Street from March 4, 1970 to December 14, 1970, when operations were halted because of water problems. Carbon monoxide only was monitored here by an Intertech nondispersive infrared device manufactured in 1970. Very little data are available on the orientation of the probe for this site; the operating environs otherwise were quite similar to those discussed for location 2.

Location 4 - This station is located on a traffic island between an on-ramp to Interstate 91 northbound and East Columbus Avenue in the vicinity of Court Street. The station has been operating since November 4, 1972. The instrumentation utilized is summarized in Table III-2.

Table III-2. AIR SAMPLING INSTRUMENTATION, EAST COLUMBUS AVENUE TRAILER, SPRINGFIELD

	Instrument			
Pollutant monitored	Make	Model	Year of manufacture	Analysis mode
Carbon Monoxide	Intertech	-	1972	Nondispersive Infrafred
Particulates (TSP)				
Oxidants	Monitor Lab	8410	1972	Chemiluminescence
Sulfur Dioxide	Philips	PW9706	1972	Coulometric Titration
Oxide of Nitrogen	Bendix Fed. Instr.	8101-B	1972	Chemiluminescence

These instruments are housed in a trailer on the site. The probe is approximately 15 feet above the mostly grass surface, about 25 feet from the edge of both East Columbus Avenue and Interstate 91. The area surrounding the site is essentially open; Interstate 91 is elevated through the area utilizing a bridge structure rather than an embankment. A large, active parking facility is located under the bridge structure near this site. Oxidant data for the AQCR were based on concentrations recorded at this location.

Location 5 - This station was located on East Columbus Avenue directly opposite the site of Location 4 described above. It was in operation from September 3, 1971 through November 10, 1973 when instrument problems and removal of the facility housing the station resulted in the termination of operations. Instrumentation utilized included an MSA Lira 200 nondispersive infrared device, manufactured in 1971, for monitoring carbon monoxide, while a Bendix, chemiluminescence device, also manufactured in 1971, was used to monitor ozone. The surrounding environs are similar to those described for Location 4.

Amherst - Only one monitor is located in Amherst. Its location is in the Western Massachusetts Public Health Center, which is essentially in a rural environment. The station became operational on August 27, 1974. Instrumentation includes a Bendix 8002 chemiluminescence device. The probe intake is 150 feet from North Pleasant Street, 30 feet above the mostly paved surface, and projects 3 feet from the south side of the building.

Future sites - Immediate plans call for establishing a monitoring station in Chicopee to be identical in instrumentation to that described for Location 4 in Springfield. As of this date, much of the instrumentation has been purchased but no start-up date has been determined. Also, a tentative proposal calls for providing an ozone monitor in the Town of Agawam.

Discussion of Site Locations[6] - The U.S. Environmental Protection Agency (EPA) has established basic guidelines for air quality monitoring systems design and siting in order to provide a consistent estimate for development and evaluation of air monitoring networks. These guidelines also provide an indication of the proper placement of the air sampling probe so as to best measure the maximum exposures that people can reasonably be expected to experience. These guidelines, however, are written assuming typical or general situations; in reality it is sometimes impractical to follow these guidelines exactly when siting a monitor because of limitations or constraints in the availability of land and power, accessability, protection from vandalism, etc. The actual siting of a sampling station involves various trade-offs between following the EPA guidelines and the practicality of the situation as dictated by the constraints mentioned.

Generally, for monitoring mobile-source pollutants; i.e., carbon monoxide and ozone, the sensor should be situated to measure short-term exposures in areas where people are actually expected to be exposed to the pollutant. The nature of carbon monoxide is such that the sensor must be situated very close to the source of emissions, but still within an area where "person-exposure" for periods of one to eight hours is probable.

Ozone, however, is quite different from carbon monoxide in that a certain time lag is involved from the time source emissions occur to the time that ozone is formed (emissions of reactive hydrocarbons undergo photochemical reaction in the atmosphere to form ozone - this reaction may occur as long as six hours or more after the hydrocarbons are emitted). Because it is highly likely that hydrocarbon emissions will be transported some distance prior to the reaction (formation of ozone) being completed, the monitoring site should be located downwind of the principal source of emissions.

Based on the considerations and EPA guidelines mentioned above, general statements can be made regarding the proper siting of pollutant monitors:

> Ozone: The preferred siting should be 5 - 15 miles downwind from the downtown portion of an urbanized area and at least 300 feet from major traffic arteries or parking areas. Downwind is defined by the prevailing wind direction during the oxidant season (usually summer).
>
> Carbon monoxide: The preferred siting for monitoring 1-hour concentrations of carbon monoxide is in a downtown area of dense, slow moving traffic where obstructions to airflow exist. The probe intake should be about 10 to 15 feet from the curb and 5 to 10 feet above the ground. For monitoring 8-hour average concentrations, the site should be generally within an area of high traffic density but not adjacent to

major thoroughfares or in the city center. The probe intake should be more than 50 feet from the street curb.

In all cases, sites should be avoided that are unduly influenced by localized sources or where airflow to the probe intake is restricted. While the siting of a monitoring station is important is must be emphasized that, within certain limits, data derived from stations not conforming to the appropriate guidelines may still be perfectly valid for analyzing an area's air quality. The Surveillance and Analysis Division of EPA accounts for these discrepancies in its verification of the validity of data derived from such stations.

The monitoring stations described previously were reviewed with regard to siting and have been found to conform within reasonable limits to established guidelines. It was concluded, therefore, that data derived from these stations would have utility in analyses of various air quality problems in the AQCR.

Review and Evaluation of Air Quality Data

Inasmuch as the Clean Air Act and pertinent EPA regulations specify that controls are to focus on reducing the worst pollution conditions to attain appropriate ambient air quality standards it is necessary to determine just how often and to what extent these standards are being violated. The procedure for determining the extent of air quality improvement required, then, must be based on the high end of the spectrum of recorded concentrations of the pollutant, rather than on the average condition. The following paragraphs discuss the air quality data available for the Region and its use in development of the Transportation Control Plan.

Carbon Monoxide - As indicated previously several carbon monoxide monitoring stations have been operated in the AQCR over the past few years.

The monitoring sites have all been located in downtown Springfield where the highest densities of slow moving traffic occur. The first station began operating in March 1970. Since then, sensors have been monitoring carbon monoxide with very few interruptions. Figure III-8 shows the operating dates of the past and present sites. It should be noted that a decision had been made during early development of the Plan to concentrate on 1972, 1973, and 1974 air quality data because data for these years were of better quality and more reliable than data previous to 1972.

Data from the monitoring sites undergo several validation processes prior to being accepted. Both the Massachusetts Department of Public Health and the EPA's Surveillance and Analysis Section perform various comparative and statistical quality control checks on the data. Therefore, in working with the data summaries provided by the Department of Public Health, it was assumed, without further analysis by GCA, that the data were valid.

Highest values - For carbon monoxide, two ambient air quality standards exist. The first is based on a maximum average concentration for a 1-hour time period, this being 35 parts per million (ppm). The National Ambient for Quality Standard (NAAQS) states that this maximum 1-hour concentration is not to be exceeded more than once per year. A review of the hourly concentrations for Springfield was made to determine how the actual measured concentrations compared with the standard. A summary of this review appears in Table III-3.

Table III-3 indicates that the primary standard of 35 ppm for one-hour concentrations of carbon monoxide was violated only once during the three-year period. Since the standard was not exceeded more than once during any one of the years for which data were available, it can be concluded that the National Ambient Air Quality Standard for 1-hour concentrations of carbon monoxide has not been violated.

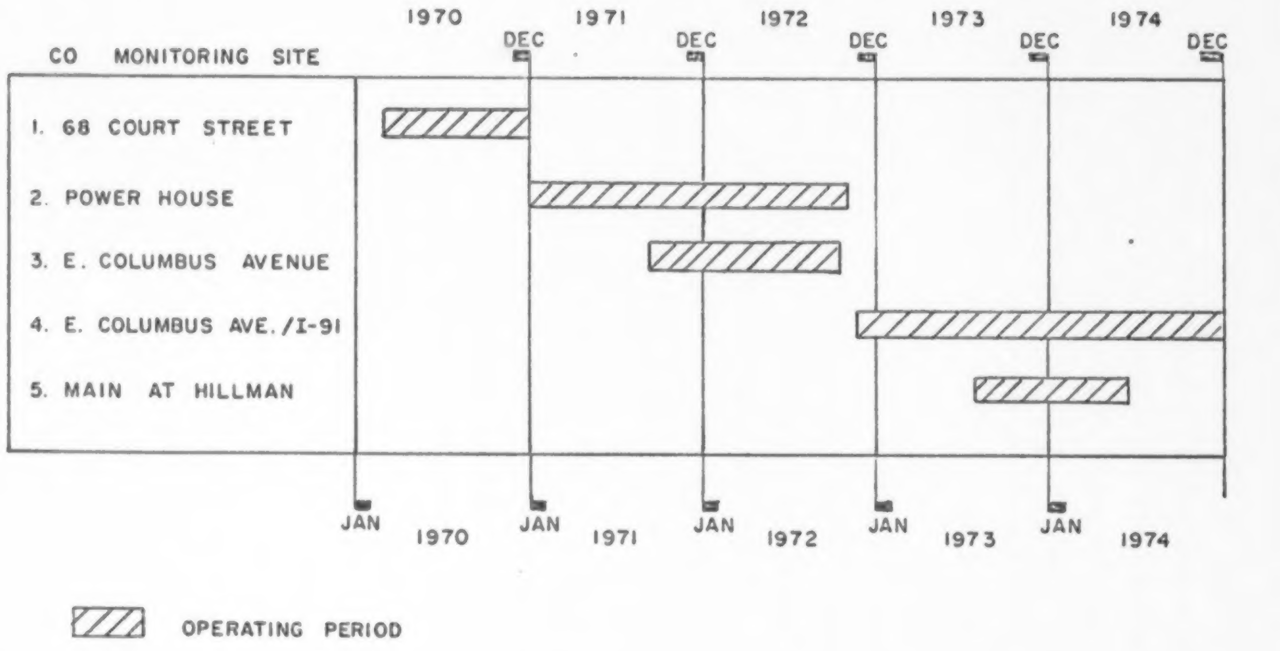

Figure III-8. Carbon monoxide monitoring station operating dates, Springfield, Massachusetts

Table III-3. HIGHEST 1-HOUR CO CONCENTRATIONS RECORDED IN SPRINGFIELD, MASSACHUSETTS, MARCH 1972 THROUGH DECEMBER 1974

Year	Highest hourly average			Second highest average		
	Concentration (ppm)	Date	Time	Concentration (ppm)	Date	Time
1972	34.0[a]	13 Jan.	1700	32.0[a]	13 Jan.	1800
1973	39.0[b]	26 Dec.	1800	34.0[b]	4 Dec.	1700
1974	30.0[b]	16 Jan.	1700	26.0[b]	16 Jan.	1800
				26.0[b]	23 Jan.	1700

[a] Recorded at East Columbus Avenue Power House

[b] Recorded at the East Columbus Avenue Trailer

The second standard relates to the 8-hour running average concentration of carbon monoxide. This states that the standard of 9 ppm for 8-hour average concentrations shall not be exceeded more than once during any calendar year. Again, the data available for Springfield were analyzed to compare the actual ambient air quality with the standard.

Tables III-4 and III-5 present a summary of the total number of 8-hour periods with average concentrations exceeding 9 ppm, as well as the number of days for each month with 8-hour averages exceeding 9 ppm, during 1972 through 1974, at the two monitoring sites on East Columbus Avenue. The same type of summary for the Main Street at Hillman Street monitoring station is presented in Table III-6.

These tables show that frequent violations of the 8-hour standard occur along East Columbus Avenue and Main Street, particularly during the winter months. The data presented in Tables III-4 and III-5 for 1973 and 1974 are for the same location while the 1972 data are for a similar location about 500 feet to the north. While these tables appear to

Table III-4. SUMMARY OF VIOLATIONS TO THE 8-HOUR NAAQS FOR CARBON MONOXIDE, FOR THREE YEARS, SPRINGFIELD, MASSACHUSETTS

Month	1972[a]			1973[b]			1974[b]		
	No. observations	No. violations	% violations	No. observations	No. violations	% violations	No. observations	No. violations	% violations
January	621	104	17	526	141	27	648	41	6
February	696	57	8	485	48	10	608	6	1
March	744	45	6	548	65	12	556	5	1
April	664	9	1	606	5	8	690	0	0
May	697	0	0	643	0	0	744	0	0
June	---	-	-	525	0	0	650	0	0
July	434	4	1	665	0	0	737	0	0
August	733	14	2	638	0	0	737	0	0
September	720	20	3	573	0	0	697	0	0
October	509	30	6	561	49	9	664	19	3
November	---	-	-	401	68	17	710	29	4
December	---	-	-	532	48	9	693	66	10
TOTAL	5818	283	4.9	6703	424	6.3	8134	166	2.0

[a] East Columbus Avenue Power House

[b] East Columbus Avenue Trailer

NOTE: Violation is considered to be an 8-hour average concentration greater than 9.0 ppm; overlapping violations are included.

Table III-5. SUMMARY SHOWING THE NUMBER OF DAYS EACH MONTH WITH VIOLATIONS TO THE 8-HOUR NAAQS FOR CARBON MONOXIDE, SPRINGFIELD, MASSACHUSETTS

Month	1972[a]			1973[b]			1974[b]		
	No. days observed	No. days with violations	% days with violations	No. days observed	No. days with violations	% days with violations	No. days observed	No. days with violations	% days with violations
January	28	15	53	27	18	67	29	7	24
February	28	6	21	23	5	22	28	3	11
March	31	5	16	27	10	37	28	2	7
April	28	1	3	28	1	3	30	0	0
May	30	0	0	31	0	0	31	0	0
June	9	2	2	28	0	0	28	1[c]	4
July	21	1	5	31	0	0	31	0	0
August	31	3	10	31	0	0	31	0	0
September	30	4	13	30	0	0	30	0	0
October	21	1	5	30	9	30	30	3	10
November	--	--	--	21	9	43	30	5	17
December	--	--	--	28	7	25	31	10	32
TOTAL	257	38	15	335	59	18	357	31	9

[a] East Columbus Avenue Power House

[b] East Columbus Avenue Trailer

[c] Data Questionable

NOTE: Violation is considered to be an 8-hour average concentration greater than 9.0 ppm; overlapping violations are included.

Table III-6. SUMMARY OF THE NUMBER OF HOURS AND THE NUMBER OF DAYS WHEN VIOLATIONS TO THE 8-HOUR NAAQS FOR CARBON MONOXIDE OCCURRED, MAIN AT HILLMAN MONITORING STATION, SPRINGFIELD MASSACHUSETTS

Month	Summary by hour			Summary by day		
	No. hours observed	No. Violations	% hours with violations	No. days observed	No. days with violations	% days with violations
August 1973	733	14	1.9	31	3	9.7
September 1973	720	20	2.8	30	4	13.3
October 1973	509	30	5.9	22	7	31.8
November 1973	720	0	0.0	30	0	0.0
December 1973	681	62	9.1	30	11	36.7
January 1974	684	9	1.3	30	3	10.0
February 1974	627	5	0.8	28	2	7.1
March 1974	704	9	1.3	31	2	6.5
April 1974	609	1	0.2	30	1	3.3
May 1974	631	0	0.0	31	0	0.0
June 1974	200	0	0.0	9	0	0.0
TOTAL	6818	150	2.2	302	33	10.9

NOTE: Violation is considered to be an 8-hour average concentration greater than 9.0 ppm; overlapping data included.

indicate that a slight improvement in air quality has occurred from 1973 to 1974, it must be emphasized that conclusions of this type cannot be assumed valid for a number of reasons, among the more important being (1) there is no information given to indicate why the apparent improvement occurred (possibly fewer days with meteorological conditions conducive to pollution incidents, or perhaps a temporary reduction in travel because of gasoline shortages, etc.); and (2) sufficient data are not available to indicate a trend. Therefore, it is important to recognize the limitations of the data presented in Tables III-4, III-5, and III-6 with respect to its usefulness as an indicator of trends in air quality.

The highest and second highest 8-hour average concentrations recorded at each of the area locations are shown in Table III-7.

The data presented in Table III-7 are useful as indicators of the magnitude of the carbon monoxide problem as determined by the monitors. Table III-7 shows that the highest 8-hour average concentrations of carbon monoxide recorded at the Main Street at Hillman Street site and the East Columbus Avenue trailer both occurred on 26 December 1973, when concentrations of 22.8 ppm and 26.6 ppm, respectively, were recorded during the 8-hour period ending at 2300 hours. These two values also represent the highest and second highest 8-hour average concentrations ever recorded in the City, as well.

It is of interest to analyze further various aspects of the air quality at the two monitoring stations during the days on which the highest concentrations were recorded. For this purpose, the hourly concentrations recorded for 26 December 1973, were plotted and compared with the average hourly concentrations for the entire month of December; these are shown in Figures III-9 and III-10. It can be seen from these two figures that the maximum hourly concentrations at both locations are greater than the average hourly concentrations for the month by a factor of 4 at Main and Hillman Streets and a factor of 5 on East Columbus Avenue.

Table III-7. HIGHEST AND SECOND HIGHEST 8-HOUR AVERAGE CARBON MONOXIDE CONCENTRATIONS AT THREE LOCATIONS, SPRINGFIELD, MASSACHUSETTS

	Highest 8-hour average[a]			Second highest 8-hour average		
Location	Concentration (ppm)	Date	Time (hr. ending)	Concentration (ppm)	Date	Time (hr. ending)
Main and Hillman	22.8	12-26-73	2300	22.1	12- 4-73	2100
E. Columbus Avenue Power House	21.5	1-11-72	2400	21.3	1-10-72	2200
E. Columbus Avenue Trailer	26.6	12-26-73	2300	19.3	1-19-73	2100

[a] For non-overlapping 8-hour time periods

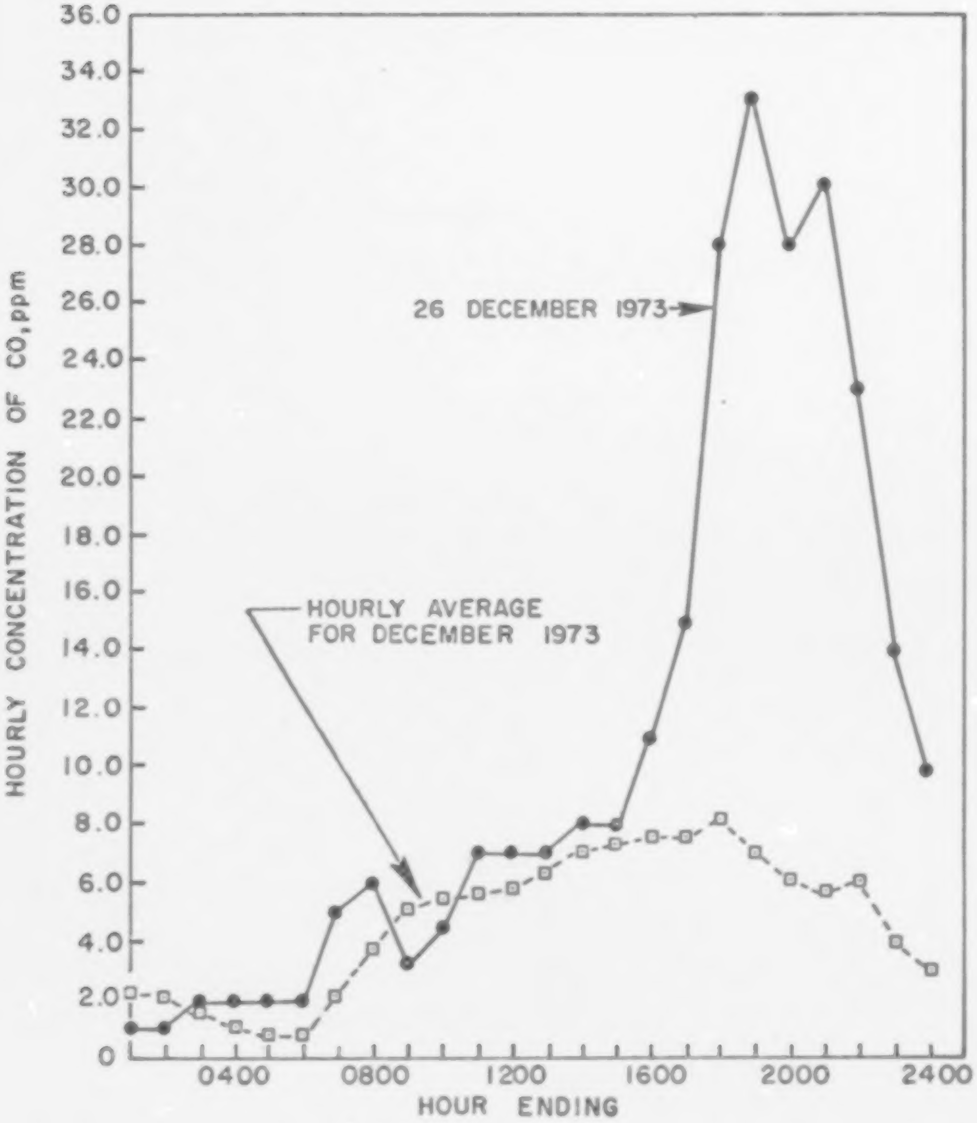

Figure III-9. Hourly average concentrations of carbon monoxide for 26 December 1973 as well as the hourly average for the entire month of December, Main Street at Hillman Streets, Springfield, Massachusetts

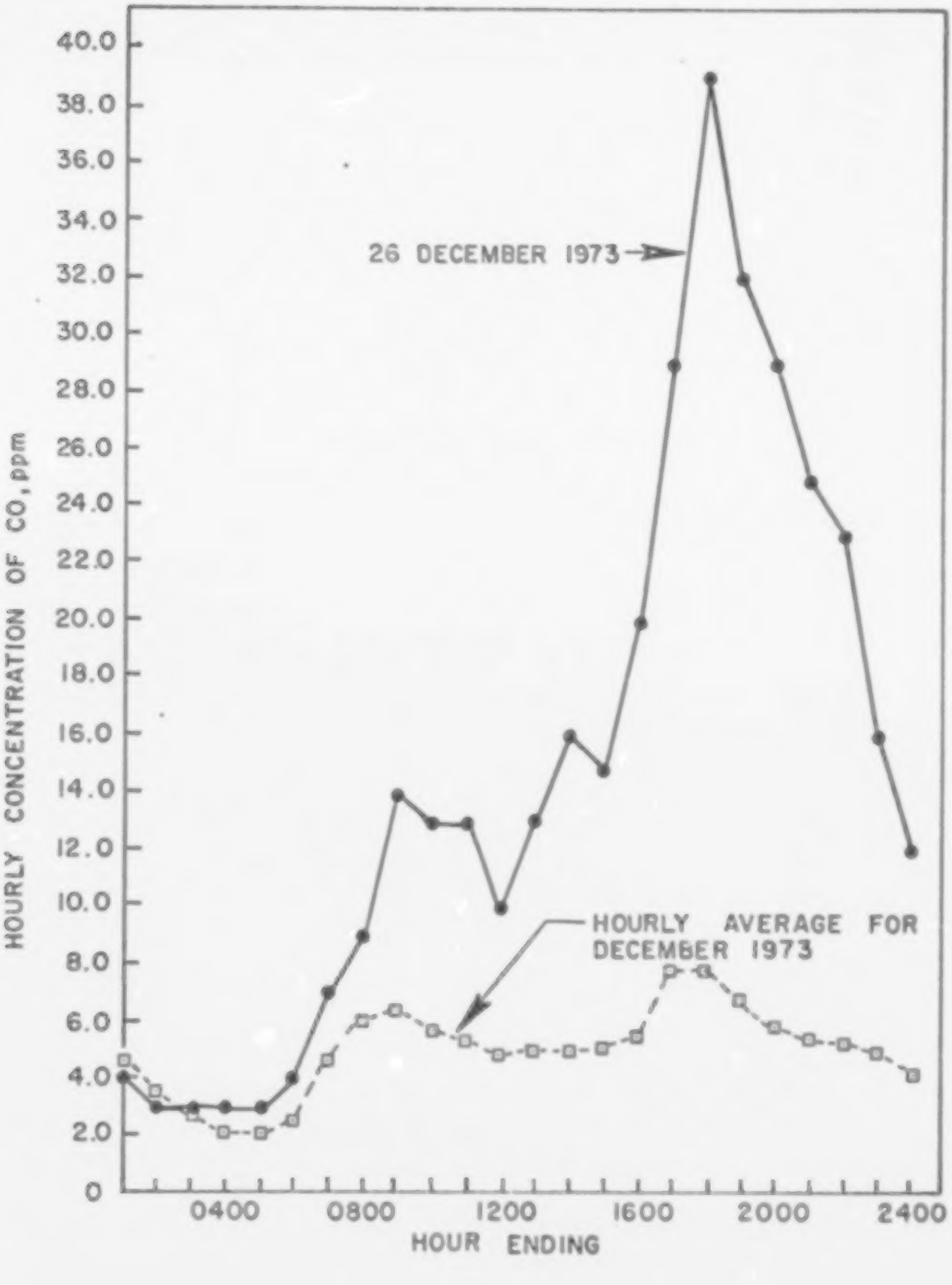

Figure III-10. Hourly average concentrations of carbon monoxide for 26 December 1973 as well as the hourly average for the entire month of December, East Columbus Avenue, Springfield, Massachusetts

The general weather conditions during the entire day on 26 December, were characterized by heavy cloud cover with periods of light rain. Winds were very light with readings of from 0 to 2 miles per hour recorded at the East Columbus Avenue monitoring site. A detailed analysis of characteristic meteorological conditions for all days when high concentrations of carbon monoxide were recorded would be in order; however, such extensive meteorological data were not available in time for inclusion in this report.

Analysis for other locations - In order to assess the air quality at other locations within downtown Springfield the APRAC-1A diffusion model, described previously, was utilized. In using this model a total of 20 theoretical receptor locations were selected as shown in Figure III-11. Data regarding the traffic operating characteristics of the entire street network during 1973 and meteorological parameters representative of the weather occurring on 26 December 1973, were then assembled for use as input. Output from the model was in the form of estimated 1-hour concentrations of carbon monoxide at each of the 20 receptors representing the "worst day" meteorological conditions. It was considered that the estimates would be more representative for longer time increments, thus average 8-hour concentrations were computed from the 1-hour concentrations. The two highest 8-hour average concentrations for each receptor location are shown in Table III-8.

It is of interest to compare the estimated concentrations with actual measured data from the two monitoring sites. Hour-by-hour comparisons of the 8-hour average concentrations (estimated and measured) at the Main and Hillman site and the East Columbus Avenue trailer are presented in Figures III-12 and III-13, respectively; these Figures warrant further discussion.

It should be noted, first of all, that the estimated concentrations shown are the results from the first computer run made. Calibration was not accomplished owing to the nonavailability of sufficient meteorological

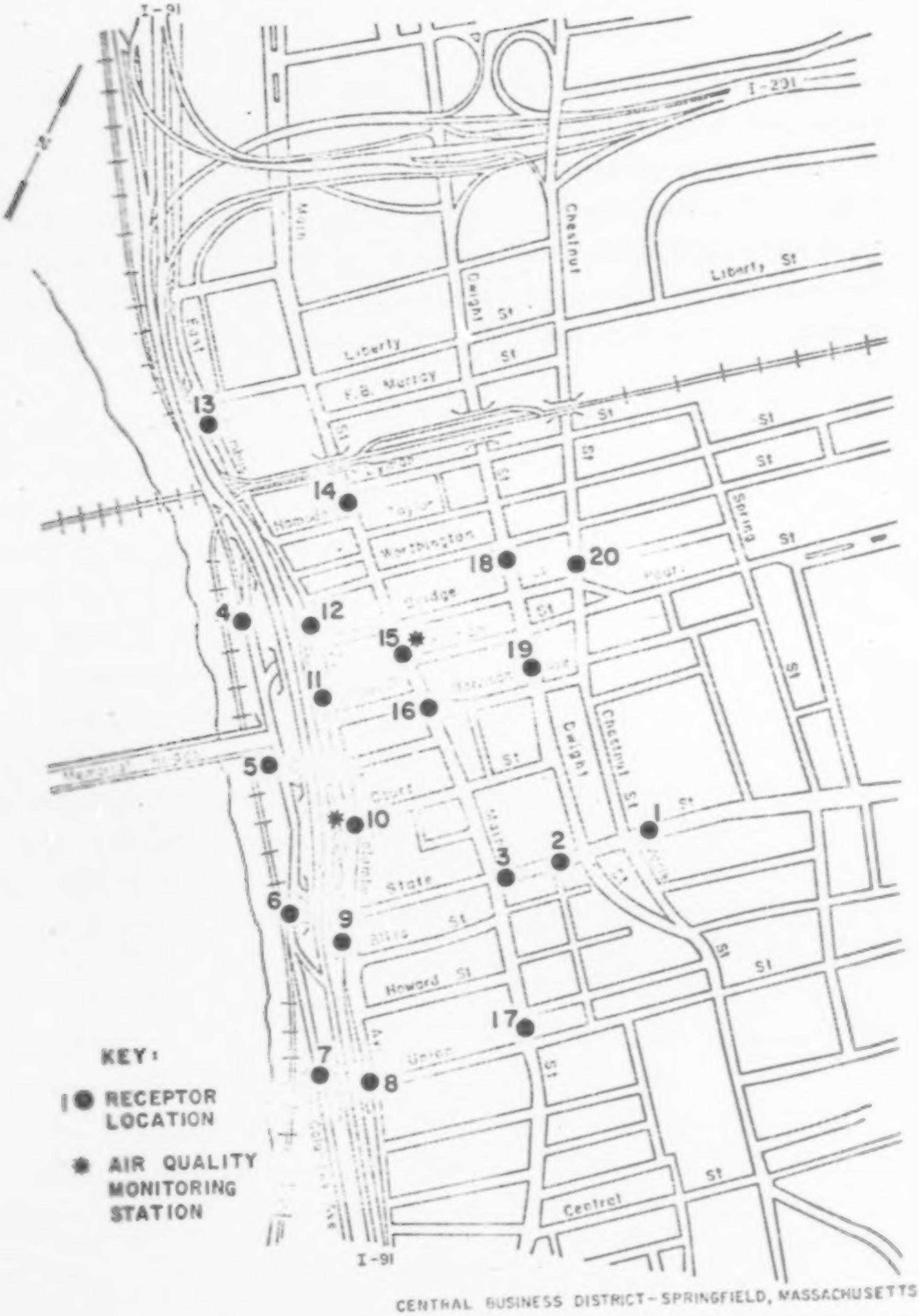
I-91
I-291
Main
Chestnut
Dwight St
Liberty St
East
Liberty
F.B. Murray
St
Taylor
Worthington
Bridge
Spring
Court
Dwight
Chestnut St
State
Elm St
Howard St
Union
Central
St
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
KEY:
RECEPTOR LOCATION
AIR QUALITY MONITORING STATION
I-91
CENTRAL BUSINESS DISTRICT-SPRINGFIELD, MASSACHUSETTS

Figure III-11. Receptor locations for APRAC-1a diffusion model analysis of downtown Springfield, Massachusetts

Table III-8. FIRST AND SECOND HIGHEST CALCULATED 8-HOUR AVERAGE CONCENTRATIONS OF CARBON MONOXIDE AT 20 LOCATIONS IN DOWNTOWN SPRINGFIELD, MASSACHUSETTS

Location	Highest concentration (ppm)	Second highest concentration (ppm)
1. State at Chestnut	6.75	6.72
2. State at Dwight	13.45	13.37
3. State at Main	12.63	12.56
4. W. Columbus at I-91 S/B Off-Ramp	9.87	9.80
5. W. Columbus at Memorial Bridge	9.61	9.55
6. W. Columbus at State	6.98	6.94
7. W. Columbus at Union	2.39	2.38
8. E. Columbus at Union	4.80	4.77
9. E. Columbus at State	8.57	8.50
10. E. Columbus at I-91 N/B On-Ramp	8.06	8.03
11. E. Columbus at Vernon	10.89	10.83
12. E. Columbus at Worthington	5.88	5.86
13. E. Columbus at Liberty	1.95	1.95
14. Main at Hampden	6.03	6.01
15. Main at Hillman	18.21	18.10
16. Main at Vernon	16.78	16.66
17. Main at Union	8.31	8.28
18. Dwight at Worthington	8.92	8.88
19. Dwight at Harrison	6.02	6.00
20. Chestnut at Bridge	4.59	4.58

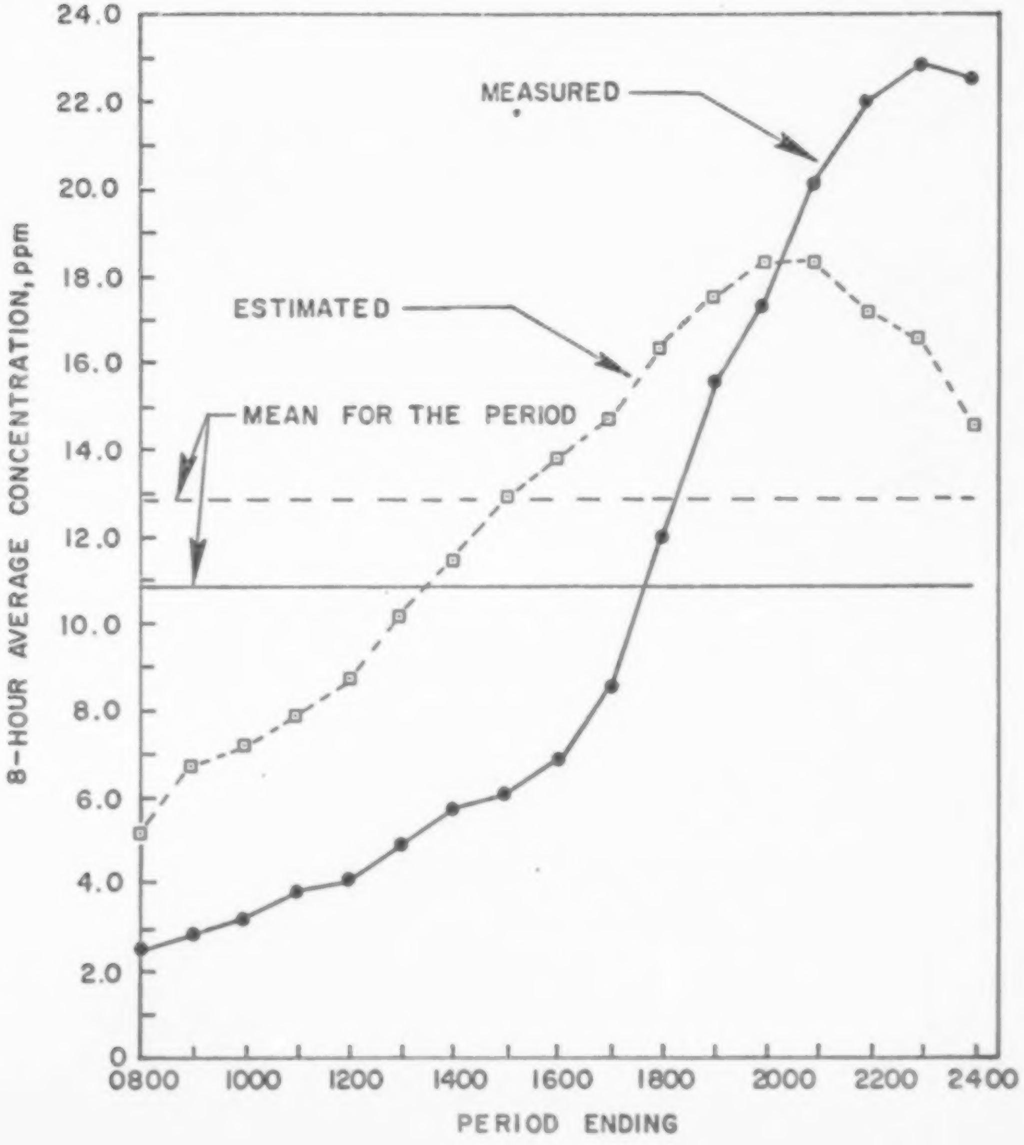

Figure III-12. Measured and estimated 8-hour average concentrations of carbon monoxide at Main and Hillman Streets, Springfield, Massachusetts

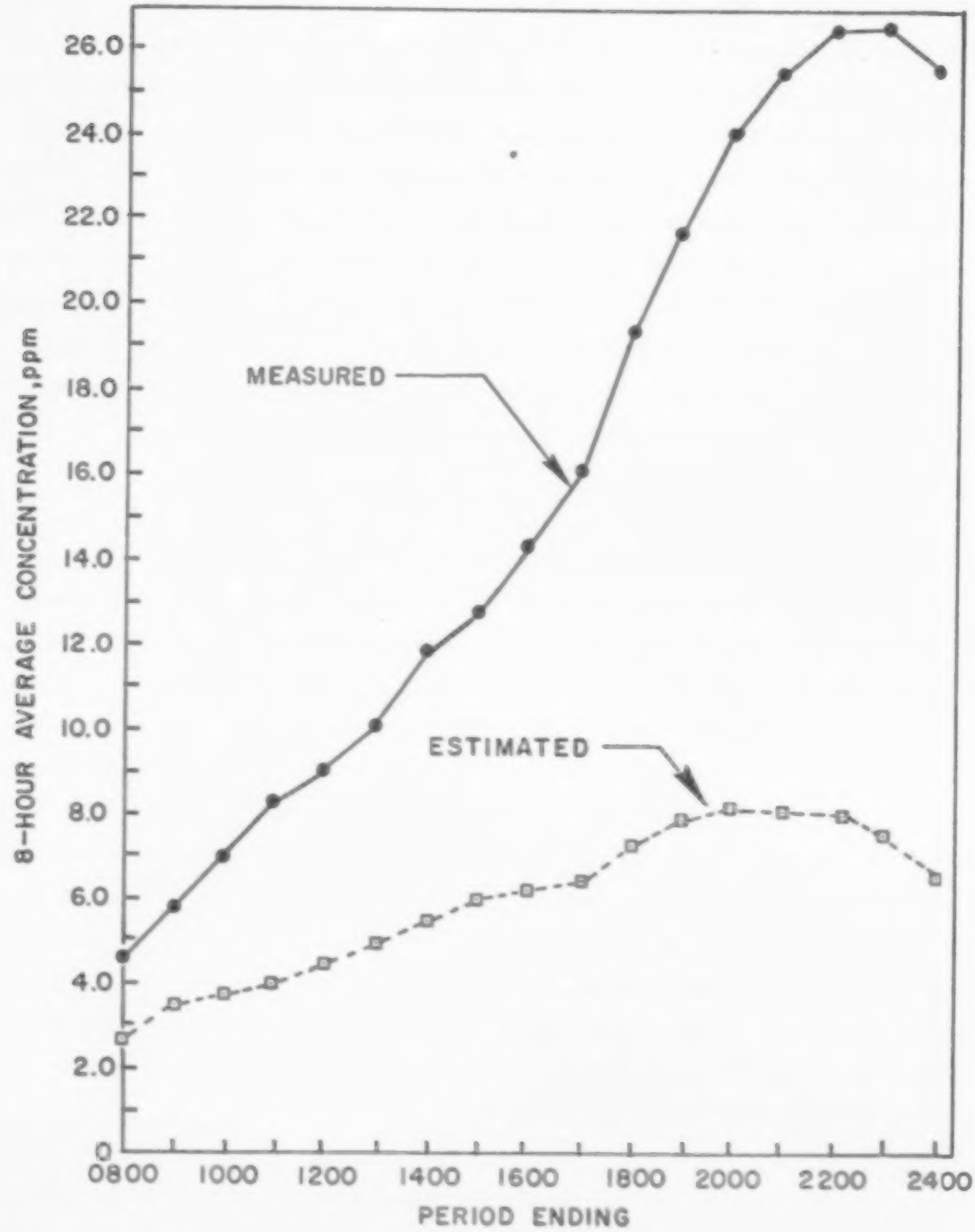

Figure III-13. Measured and estimated 8-hour average concentrations of carbon monoxide on the East Columbus Avenue, Springfield, Massachusetts

data. The data for Main and Hillman Streets, shown in Figure III-14, will be discussed first. It is apparent that the model overestimated concentrations for much of the day with calculated 8-hour averages for the periods ending at 0800 through 1700 hours consistently overestimated by a factor of about 2. Beyond 1700 hours, the disparity between the calculated and measured data decreases until about 2000 hours when the maximum calculated concentration occurs. From this point, the calculated concentrations decrease with time; the measured concentrations, however, continue to increase until 2300 hours when a maximum 8-hour average concentration is achieved. For the entire period shown, the mean 8-hour average values for calculated and measured concentrations are 12.8 ppm and 9.9 ppm, respectively.

It is important to note that traffic data input for the model consisted of factors for average characteristics of traffic density and speed. Given the particular type of weather experienced on 26 December 1973, and the probable impact of the Christmas Holiday, it is logical to conclude that average traffic density and speed characteristics did not prevail on that day. Also, the model does not permit analysis of completely calm (zero wind) wind conditions - a minimum wind speed of 1 meter per second must be assumed. Meteorological data from Westover Air Force Base indicated that calm conditions existed after 1800 hours (zero wind as opposed to wind speeds of 2 to 6 knots during the earlier part of the day). This condition probably accounts for the increasing concentrations (measured) after 1800 hours even though traffic volumes, and consequently emission rates, probably decreased substantially after 1800 hours.

Despite the differences in the estimated and measured data displayed by Figure III-12, it is anticipated that once meteorological data becomes available, the model can be calibrated so that it will provide more accurate estimates of carbon monoxide concentrations at locations similar to the Main Street at Hillman Street site. Even uncalibrated as it is now, it provides valuable information regarding the relative potential for the existence of carbon monixide problems elsewhere in downtown Springfield and for evaluation of the relative effects of alternative traffic control strategies.

The comparison of measured and calculated concentrations at the East Columbus Avenue trailer shown in Figure III-13 indicates serious underestimation by the model. The difference between measured and calculated CO concentrations may be attributed to several factors. In the first place the vicinity of the East Columbus Avenue trailer does not fit the standard description of a street canyon. For the very low wind speeds observed during the validation day, the model predictions could be considerably in error if the actual wind speed is below the 1.0 meters per second minimum value assumed in the model. Also the emissions from a given link are actually distributed uniformly over the area of a radial sector so that background contributions from nearby roadways could be underestimated by the model. As a check on the APRAC analysis the EPA's HIWAY computer model was used to analyze the impact that emissions from I-91 traffic have on the concentrations monitored at the East Columbus Avenue Trailer. For this analysis the "worst hour" meteorological conditions were used; these included a wind direction of 220 degrees, wind speed of 1.0 meters per second, stability Class D, and a mixing depth of 1000 meters. The model results indicated that the concentration at the monitoring station resulting from I-91 traffic alone would be 13.3 ppm, while the concentration resulting from traffic from the on-ramp to I-91 would be approximately 1.4 ppm. Although the HIWAY predictions are somewhat closer to the measured values than those of APRAC, they are still far too small. If the wind speed associated with this "calm" condition was taken to be 0.4 meters per second (1 mi/hr) instead of 1 meter per second, the predicted concentration would be 33.2 ppm.

Contractual limitations did not permit a more thorough analysis; however, it is considered that further investigation would serve to substantiate the implications of the above - these being that (1) the air quality adjacent to and downwind of I-91 is most strongly affected by emissions generated on I-91; (2) the concentrations shown in Table III-8 for locations on East Columbus Avenue are substantially underestimated; and (3) the utilization of the HIWAY model may provide more accurate assessments of air quality along East Columbus Avenue, and possibly West Columbus Avenue as well.

From Table III-8 and the discussion above, it can be concluded that the National Ambient Air Quality Standard for the maximum permissable 8-hour concentration of carbon monoxide has been exceeded in downtown Springfield on a significant number of occasions. Because it has also been shown that there is some consistency in the pattern of violations it is prudent to expect that strategies must be developed to reduce the ambient concentrations to an acceptable level; these strategies will be defined and analyzed in Section IV of this document.

Oxidants - Currently, there are two sampling stations in operation within the AQCR where oxidants in the form of ozone are monitored. An additional station was operated temporarily so that data are available for the time peiod beginning in October 1971 through December 1974. Numerous instrumentation problems, however, resulted in some discontinuity in the data. The only overlapping data consist of oxidant concentrations monitored from October through December 1974 in downtown Springfield and Amherst. For consistency and because data from the Amherst station were not received by GCA until late in the study, analyses are limited to data from the Springfield stations.

Oxidants data, like carbon monoxide data, undergo various quality assurance checks by both the Massachusetts Department of Public Health and the EPA's Survaillence and Analysis Section. Therefore, data received from the Department of Public Health were considered valid without further checking.

Highest values - The National Ambient Air Quality Standard for a 1-hour average concentration of oxidants is 0.08 ppm; this standard is not to be exceeded more than once during any year. A review of the data available was made to determine maximum concentrations; these are shown in Table III-9.

Table III-9. HIGHEST 1-HOUR OX CONCENTRATIONS RECORDED IN THE AQCR, JUNE 1972 THROUGH DECEMBER 1974

Year	Highest hourly average			Second highest average		
	Concentration (ppm)	Date	Time	Concentration (ppm)	Date	Time
1972[a]	0.060	14 July 22 August	2000 2000	0.055	22 August	1800
1973	0.145	16 June	1500	0.134	5 June	1900
1974	0.116	29 April	1900	0.108	30 June	1800

[a] Data available for 4 months only.

It is also of interest to analyze the hourly distribution of ozone concentrations for the days during which the highest concentrations occurred. Figures III-14 and III-15 show this distribution for the days during which the highest concentrations during 1973 and 1974 occurred.

Frequency of violations - The available data were also reviewed to determine the number of times the standard was exceeded; Table III-10 provides a summary of this review.

Table III-10 shows that the primary standard for photochemical oxidants is being exceeded occasionally within the AQCR. A very cursory review of this Table might lead one to conclude that, based on a comparison of 1973 with 1974 data, the problem is decreasing; this, however, cannot be considered a valid conclusion since it has been shown that meteorology has an important influence on the development of oxidants but meteorological

Table III-10. SUMMARY OF VIOLATIONS TO THE 1-HOUR NAAQS FOR OXIDANTS, SPRINGFIELD, MASSACHUSETTS

Month	1972			1973			1974		
	No. observations	No. violations	% violations	No. observations	No. violations	% violations	No. observations	No. violations	% violations
January	---	-	----	---	--	----	150	0	0.00
February	---	-	----	634	0	0.00	662	0	0.00
March	---	-	----	731	0	0.00	739	0	0.00
April	---	-	----	703	0	0.00	702	3	0.43
May	---	-	----	635	11	1.73	173	0	0.00
June	700	0	0.00	680	18	2.64	710	3	0.42
July	733	0	0.00	728	15	2.06	---	-	----
August	731	0	0.00	686	10	1.46	729	1	0.14
September	601	0	0.00	710	3	0.42	715	0	0.00
October	---	-	----	647	6	0.93	731	0	0.00
November	---	-	----	611	0	0	---	-	----
December	---	-	----	711	0	0	---	-	----
Total	2765	0	0.00	7476	63	0.84	5311	7	0.13

NOTE: A violation is any hourly average greater than 0.08 ppm.

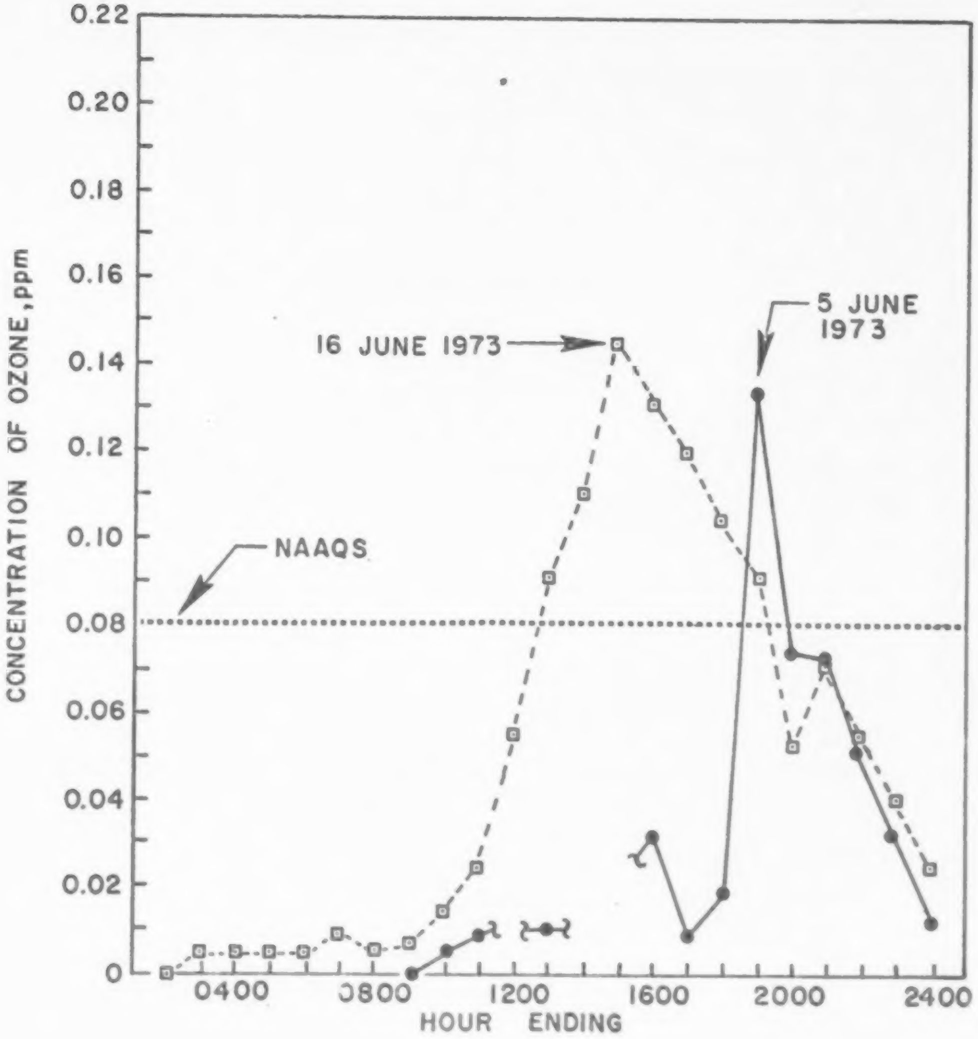

Figure III-14. Diurnal distribution of ozone concentrations for June 5 and June 16, 1973, Springfield, Massachusetts

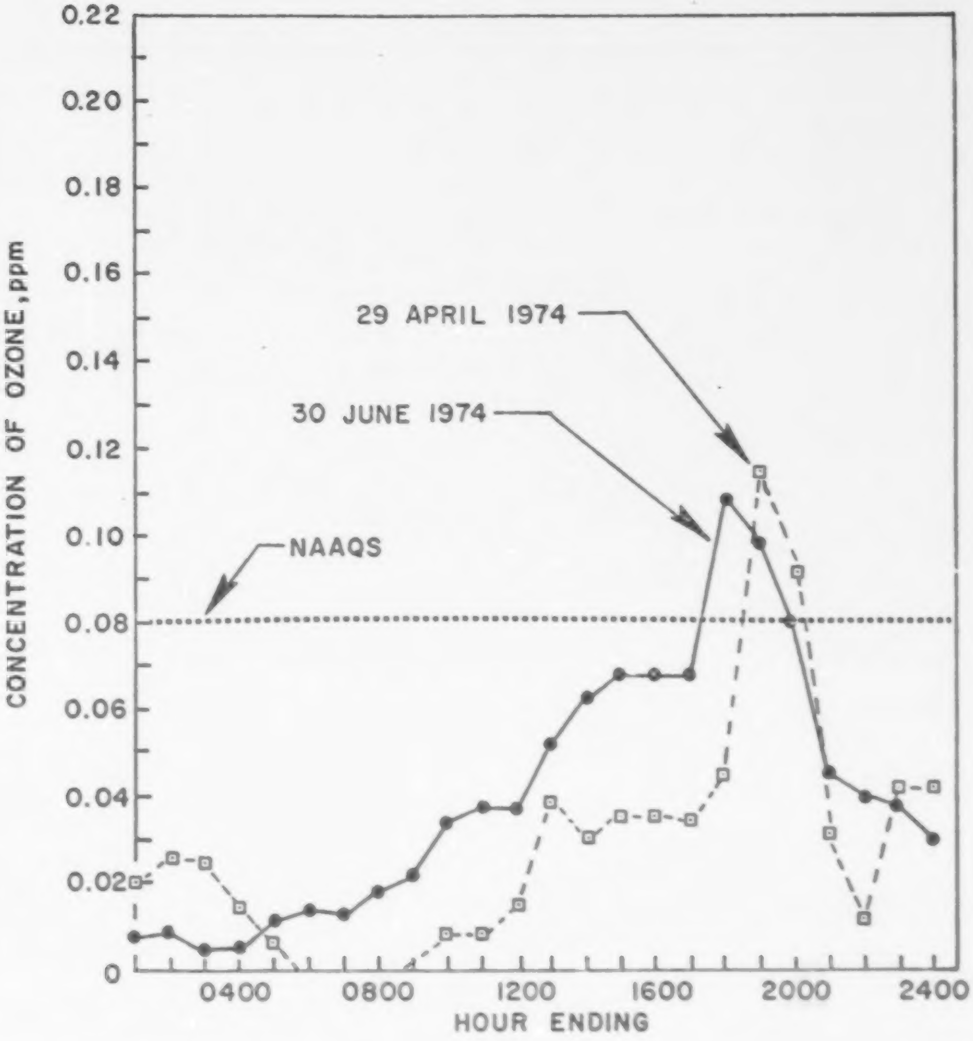

Figure III-15. Diurnal distribution of ozone concentrations for 29 April and 30 June, 1974, Springfield, Massachusetts

patterns are essentially nonrepetitive on a yearly basis. Therefore, it is totally invalid to infer the existence of any trends in the data displayed.

Validity of data - The issue addressed here is with regard to whether the data obtained from the monitoring site in Springfield are representative of the AQCR as a whole. It was indicated earlier that EPA has developed various guidelines for the siting of monitoring stations. According to these guidelines, a station for monitoring oxidants should be located 5 to 15 miles downwind from an urbanized area and at least 300 feet from major traffic arteries or parking areas.[6] The East Columbus Avenue monitoring station, however, is actually upwind of the urbanized area and is located within 300 feet of both a major parking facility and an important arterial.

The implications of the station siting are open to some speculation. However, it is felt that, in general, the data derived from the station are valid and do indicate the existance of an oxidant problem in the AQCR even though the station may not be ideally located to monitor maximum concentrations of oxidants. Further, it appears that the Amherst station is more ideally suited to monitor maximum oxidant concentrations but, again, the station has not been operating for a sufficient period of time to provide adequate data (in the quantitative sense).

In conclusion, then, it can be seen that there is a definite air quality problem in the AQCR with respect to photochemical oxidants concentrations, and, again, it is reasonable to expect that strategies must be devised to reduce these concentrations, accordingly. Also, it is emphasized that data covering the period through December 1974 only were included in the analysis. This means that no data were analyzed for the "peak oxidants season" at the Amherst Station.

BASELINE EMISSIONS

General

In developing the proposed Transportation Control Plan, it was necessary to determine present and estimated future emissions from all major sources of each of the pollutants of interest (carbon monoxide and hydrocarbons). The following paragraphs present a discussion of how baseline emissions of each pollutant were determined and concludes by identifying the degree of emissions reduction estimated to be required in order to meet the National Ambient Air Quality Standards (NAAQS).

Carbon Monoxide Emissions

The principal source of carbon monoxide emissions is the motor vehicle. It has been emphasized that the presence of high concentrations of carbon monoxide is a very localized phenomenon, i.e., concentrations decrease rapidly with distance from the specific emission source. Therefore, it follows that an important aspect in the analysis of carbon monoxide problems involves the identification of specific locations where maximum emission rates occur. Again, for carbon monoxide, these locations would be adjacent to streets or highways which carry high volumes of slow-moving traffic, particularly within areas where wind flow is restricted (e.g. city streets surrounded by high buildings). For this report, the area studied with regard to carbon monoxide was limited to downtown Springfield where traffic density, traffic speed, and wind flow characteristics are most conducive to formation of high pollutant concentrations (this does not imply that there might not be other locations where carbon monoxide standards are violated, however).

In previous paragraphs it was indicated that the method utilized in the analysis of carbon monoxide for Springfield involved the use of the APRAC computer model to estimate air quality directly. It was also indicated that the model was basically a tool for correlating meteorological characteristics with emissions characteristics to develop the resulting air quality estimates.

The emission rate (any pollutant) of a vehicle is a function of the travel speed, effectiveness of any pollution control systems utilized, relative size (type) of the vehicle, and the particular engine mode (gasoline or diesel) utilized. The emissions characteristics of a particular street or highway, then, are a function of the net characteristics of all vehicles using that facility, or, stated differently, a function of the average traffic speed, vehicle age distribution, distribution of vehicles by size and engine type, and the daily traffic volume on the facility.

In the analysis of carbon monoxide concentrations in downtown Springfield the parameters defined above were established through a traffic study (see Appendix E) conducted by GCA/Technology Division and data available from various State and local agencies. The following is a brief discussion of these parameters.

Traffic Speeds - Average travel speeds for the major streets in downtown Springfield were determined during the traffic study through "Speed and Delay" analysis techniques. Average speeds for minor streets were estimated based on field observations and sample Speed and Delay analyses. Streets and sections of streets were then designated with one of several speed classification codes which are shown in Table III-11.

Speed ranges rather than absolute speeds were used in calculating emissions for two reasons. First, speed values are in terms of average daily speed. This means that if one were to determine an absolute value for average daily speed, a very large number of Speed and Delay runs would be required. This is not deemed desirable because of time and economic constraints and also because the accuracy of other data elements does not warrant this degree of accuracy. The assumed speed for each classification code was based on the weighted average of oberved and estimated speeds within the corresponding speed range for that classification.

Table III-11. SPEED CLASSIFICATIONS UTILIZED FOR CARBON MONOXIDE EMISSIONS COMPUTATIONS FOR SPRINGFIELD, MASSACHUSETTS

Calculated or estimated speed (mph)	Assumed speed (mph)	Speed Classification Code
0 - 9	8	1
10 - 15	12	2
16 - 25	21	3
26 - 35	28	4
> 35	45	5

Vehicle-Age Distribution - This parameter was determined from questionnaire data obtained from the traffic study. Its use in calculating emissions is important because emission rates are not the same for vehicles of different model years. This is so because the types and effectiveness of pollution control devices vary with model year and also because these devices tend to become less effective as the vehicle accumulates mileage (accumulated mileage correlates very closely with vehicle age). Table III-12 summarizes the vehicle age distribution determined for Springfield.

Distribution by Vehicle Type - During the field investigations in Springfield several classification counts were made by GCA to determine the distribution of vehicles by type on the downtown street system. Vehicles were classified according to the following categories: passenger cars or pickup trucks, single-unit trucks, buses, and tractor-trailer combinations. It was found that approximately 95 percent of the vehicle population on local streets consisted of passenger cars or light trucks while heavier trucks and buses accounted for only 5 percent of the population. Further analysis of truck and bus categories indicated that the ratio of diesel-powered to gasoline-powered trucks and busses on the local streets was about 3:2.

Table III-12. VEHICLE-AGE DISTRIBUTION, SPRINGFIELD, MASSACHUSETTS[a]

Vehicle[b] age (years)	Percentage of total vehicle population
< 1	1.3
1	14.4
2	15.6
3	14.1
4	11.3
5	11.4
6	9.0
7	8.3
8	4.7
9	3.9
10	3.1
11	1.6
12	1.0
13 or older	0.3
	100.0

[a] As of 31 December 1974

[b] Vehicle age with respect to model year, < 1 indicating the current model year.

Source: Traffic survey by GCA/Technology Division.

Traffic Volumes - Traffic volume data were acquired from the Springfield Traffic Engineering Department, The Massachusetts Department of Public Works, and counts taken during the traffic study. These data consisted of automatic traffic recorder counts of from 24 to 72 hours in duration, as well as a number of short-term 1- to 2-hour manual counts. Data from the questionnaire survey taken during the downtown traffic study made it possible to verify count data and to develop estimates of traffic volumes on streets where counts were not taken. Hourly as well as directional distributions were also determined for several locations.

Emissions Calculations - The data elements described above were then aggregated into two sets - the first set being link data which described traffic volume and speed characteristics particular to each street or street segment (these are shown in Appendix F); and the second set being general data, including vehicle age and type distribution, which were considered constant throughout the street network. A computer program, VEHEMI-13, was then utilized to calculate carbon monoxide emissions throughout the street network based on exhaust emission factors applied to the parameters just described. The emission calculations were actually accomplished as an internal operation during the APRAC air quality analysis; the value, again, of carbon monoxide emissions data is with respect to its use in combination with meteorological data to estimate air quality.

Hydrocarbon Emissions

It was established in earlier text that oxidants are formed by photochemical reactions involving reactive hydrocarbons. Thus, there really are no direct emissions of oxidants, per se, but, rather, emissions of hydrocarbons which may form oxidants. It is therefore necessary to investigate the sources of hydrocarbons. It was also mentioned previously that there are four basic sources of hydrocarbon emissions; these being vehicular sources, nonvehicular (stationary) sources, natural sources, and transport from upwind locations.

Natural Sources - Natural sources of reactive hydrocarbons are judged to be insignificant within the AQCR and will, therefore, be disregarded in this study.

Transport from Upwind Sources - Some discussion of the transport phenomenon was presented earlier. In essence, it was concluded that the impact of transport on the subsequent formation of oxidants downwind could not be determined with any degree of certainty from the technology and data currently available. It must suffice to acknowledge the possibility that hydrocarbons or oxidants are being transported into the AQCR from upwind areas; this light treatment of transport is by no means intended to diminish the potential importance of the subject, however.

Vehicular Sources - The parameters that must be considered in the calculation of hydrocarbon emissions are essentially identical to those considered for carbon monoxide. But, because the principal manifestation of hydrocarbon emissions is the formation of oxidants at some distant point in time and space, analysis of emission sources must focus on very large areas. As a point of interest, the analysis of vehicular characteristics for the carbon monoxide study focused on an area of approximately 1 square mile which included approximately 20 miles of roadway, while the hydrocarbon emissions analysis involved an area of approximately 1856 square miles and included about 5500 miles of highway. Obviously the approach used in establishing the various parameters for the hydrocarbon emissions analysis differed from that used for the carbon monoxide study. The following paragraphs discuss the development of parameters used in calculating the baseline (1973) emissions of hydrocarbons in the AQCR.

A principal source of the required travel data was the Massachusetts Department of Public Works, Bureau of Transportation Planning and Development. This agency provided estimates of vehicle-miles of travel (VMT) and actual roadway mileage for various highway types in each of the three counties. A summary of these data is presented in Table III-13.

Table III-13. SUMMARY OF VEHICLE-MILES OF TRAVEL AND ROADWAY MILEAGE FOR FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES, 1973

County	Highway[a] type	Urban portion		Rural portion		Total	
		Miles	DVMT	Miles	DVMT	Miles	DVMT
Franklin	Expressway	4.01	54,600	20.21	220,600	24.22	275,200
	Arterial, Collectors	40.68	170,200	572.16	665,300	612.84	835,500
	Local	69.88	10,482	831.50	62,363	901.38	72,845
	TOTAL	114.57	235,282	1,423.87	948,263	1,538.44	1,183,545
Hampden	Expressway	45.47	1,078,000	27.20	479,700	72.67	1,557,700
	Arterial, Collectors	490.27	3,344,000	369.77	598,000	860.04	3,942,000
	Local	995.56	224,000	506.75	38,000	1,502.31	262,000
	TOTAL	1,531.30	4,646,000	903.72	1,115,700	2,435.02	5,761,700
Hampshire	Expressway	6.57	115,600	3.73	41,400	10.30	157,000
	Arterial, Collectors	176.40	665,500	425.21	594,700	601.61	1,260,200
	Local	289.17	65,100	621.57	46,618	910.74	111,718
	TOTAL	472.14	846,200	1,050.51	682,718	1,522.65	1,528,918
Total	Expressway	56.05	1,248,200	51.14	741,700	107.19	1,989,900
	Arterial, Collectors	707.35	417,970	1,367.14	1,858,000	2,074.49	6,037,700
	Local	1,354.61	299,582	1,959.82	146,981	2,314.43	446,563
	TOTAL	2,118.01	5,727,482	3,378.10	2,746,681	5,496.11	8,474,163

[a] As defined in the National Highway Classification Study

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development; estimates by GCA

An assumed average travel speed was assigned to each of the highway classifications based on professional judgment; these are shown in Table III-14.

Table III-14. ASSIGNED VALUES REPRESENTING AVERAGE TRAVEL SPEED BY HIGHWAY CLASSIFICATION, FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

County	Highway classification[a]	Assigned average travel speed (mph)
Franklin	Freeway	50
	Arterial, collector	40
	Local	35
Hampden	Freeway	50
	Arterial, collector	40
	Local	30
Hampshire	Freeway	50
	Arterial, collector	40
	Local	30

[a] As defined in the National Highway Classification Study.

The distribution of VMT by vehicle type was determined from vehicle registration data obtained from R. L. Polk, Company, the Massachusetts Bureau of Taxation, and road user data developed by the U.S. Department of Transportation, Federal Highway Administration. This distribution is shown in Table III-15.

The final element determined was the vehicle-age distribution for the three counties. This was determined from vehicle registration data obtained from the R. L. Polk Company, and data obtained from the Springfield traffic survey mentioned previously. The distribution determined is presented in Table III-16.

Table III-15. DISTRIBUTION OF DAILY VEHICLE-MILES OF TRAVEL (DVMT) BY VEHICLE CLASSIFICATION, FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES, 1973

Vehicle Class[a]	Franklin County		Hampden County		Hampshire County		Total	
	DVMT	% total	DVMT	% total	DVMT	% total	DVMT	% total
LDV	881,741	74.5	4,292,467	74.5	1,139,044	74.5	6,313,252	74.5
LDT	142,025	12.0	691,404	12.0	183,470	12.0	1,016,899	12.0
HDV	59,177	5.0	288,085	5.0	76,446	5.0	423,708	5.0
MC	4,718	0.4	23,046	0.4	6,115	0.4	33,879	0.4
LDDV	1,200	0.1	5,762	0.1	1,529	0.1	8,491	0.1
HDDV	94,684	8.0	460,936	8.0	122,313	8.0	677,933	8.0
TOTAL	1,183,545	100.0	5,761,700	100.0	1,528,917	100.0	8,474,162	100.0

[a] LDV = Light-duty vehicles (passenger cars)
LDT = Light-duty trucks (pickups, panels)
HDV = Heavy duty vehicles (over 10,000 lb GVW)
MC = Motorcycles
LDDV = Light-duty diesel vehicles (passenger cars)
HDDV = Heavy-duty diesel vehicles

Table III-16. VEHICLE-AGE DISTRIBUTION, FRANKLIN, HAMPDEN, HAMPSHIRE COUNTIES[a]

Vehicle age[b] (years)	Percent of vehicle-type population	
	LDV only	Other vehicle types except MC
< 1	1.2	1.1
1	14.1	9.0
2	15.0	10.5
3	13.5	8.5
4	11.0	8.0
5	11.4	8.3
6	9.4	7.5
7	8.6	6.4
8	4.9	5.4
9	4.3	4.5
10	3.3	3.4
11	1.9	3.6
12	1.0	3.1
> 12	0.4	20.7

[a] As of 31 December 1973

[b] Vehicle age with respect to model year, < 1 indicating the current model year

Average daily emissions were calculated from the data above using the VEHEMI-13 computer program. A summary of the calculated hydrocarbon emissions from vehicular sources is presented in Table III-17.

Table III-17. SUMMARY OF DAILY HYDROCARBON COMMISSIONS FROM VEHICULAR SOURCES, FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES, 1973

Source	Calculated emissions kg/day	% of total vehicular emissions
Gasoline-powered, light-duty vehicles (LDV)	32,988	62.3
Gasoline-powered light-duty trucks (LDT)	8,887	16.8
Gasoline-powered, heavy-duty vehicles (HDV)	7,729	14.6
Motorcycles (MC)	186	0.4
Diesel-powered, light-duty vehicles (LDDV)	4	insignificant
Diesel-powered, heavy-duty vehicles (HDDV)	3,118	5.9
Total	52,912	100.0

Nonvehicular Sources - Under this general category are several groupings of specific hydrocarbon emission sources, including fuel combustion of stationary and transportation (nonautomotive) sources, solid waste disposal, process and evaporative losses, and miscellaneous sources. Emissions data for each source within the AQCR were obtained through a comprehensive hydrocarbons emissions inventory performed by GCA/Technology Division during the period November 1974 through February 1975, (see Volume II). Information on stationary source and nonautomotive transportation fuel combustion, solid waste disposal, and miscellaneous sources, was determined through search of existing National Emission Data System (NEDS) files while data relative to process and evaporative hydrocarbon emissions were obtained through a questionnaire survey. For details of this inventory, the reader is directed to Volume II, a summary of which appears in Appendix G of this document.

Table III-18 presents a summary of baseline hydrocarbon emissions from all nonvehicular sources in the AQCR as determined by the emissions inventory.

Table III-18. SUMMARY OF HYDROCARBON EMISSIONS FROM NONVEHICULAR SOURCES FOR 1973 IN FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Source category	Total hydrocarbon[a] missions, 1973 kg/day	Reactive hydrocarbon[a] emissions only, 1973 kg/day
Dry cleaning	2,078	208
Degreasing	1,427	514
Surface coating	36,623	27,218
Manufacturing	4,511	2,732
Bulk petroleum storage	2,291	2,291
Fuel combustion	2,075	2,075
Solid waste incineration	793	793
Gasoline marketing	6,691	6,691
Aircraft, LTO's	122	122
Railroad and vessels	1,014	1,014
Total	57,625	43,658

[a] Based on an inventory of 1974 emissions.

Summary of Hydrocarbon Emissions - Since photochemical oxidants are produced from reactive hydrocarbons regardless of the emission source, it is appropriate to summarize the previous analysis of individual source categories; Table III-19 provides this summary.

Table III-19. SUMMARY OF REACTIVE HYDROCARBON EMISSIONS FROM ALL SOURCES IN FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES, 1973

Emissions source categories	Emissions source	1973 emissions Kg/day	% of total
Vehicular sources	Light-duty vehicles	32,988	34.2
	Light-duty trucks	8,887	9.2
	Heavy-duty vehicles	7,729	8.0
	Motorcycles	186	0.2
	Light-duty diesel vehicles	4	Insignificant
	Heavy-duty diesel vehicles	3,118	3.2
Subtotal		52,912	54.8
Nonvehicular sources	Dry cleaning	208	0.2
	Degreasing	514	0.5
	Surface coating	27,218	28.2
	Manufacturing	2,732	2.8
	Bulk petroleum storage	2,291	2.4
	Fuel combustion	2,075	2.2
	Solid waste incineration	793	0.8
	Gasoline marketing	6,691	6.9
	Aircraft, LTO's	122	0.1
	Railroad and vessels	1,014	1.1
Subtotal		43,658	45.2
Natural sources	Considered insignificant	-	-
Subtotal		-	-
Transport from upwind sources	Not determined	-	-
Subtotal		-	-
Total		96,570	100.0

Baseline Emissions Reduction Required

Carbon Monoxide - Data presented in previous text indicated that 1-hour average concentrations of carbon monoxide exceeded the corresponding National Ambient Air Quality Standard on only one occasion for the period of record. The 8-hour standard, however, was exceeded on numerous occasions indicating that these 8-hour average concentrations must be reduced to comply with provisions of the Clean Air Act. The baseline value (defined as the second-highest nonoverlapping, 8-hour concentration exceeding the standard) for determining the extent of reduction required at the Main Street at Hillman Street monitoring station was found to be 22.1 ppm; this 8-hour average concentration was recorded at the monitoring station during the period ending at 2100 hours on 4 December 1973. The baseline value for the East Columbus Avenue station is 19.3 ppm, which was recorded on 19 January 1973 during the averaging period ending at 2100 hours.

Since the applicable standard indicates a maximum concentration of 9 ppm, the reductions required are:

$$\text{Main at Hillman:} \quad \frac{22.1\ \text{ppm} - 9.0\ \text{ppm}}{22.1\ \text{ppm}} \times 100 = 59\%$$

$$\text{East Columbus Avenue:} \quad \frac{19.3\ \text{ppm} - 9.0\ \text{ppm}}{19.3\ \text{ppm}} \times 100 = 54\%$$

On the basis of the linear rollback relationship used for this report, required reductions in 8-hour average carbon monoxide emissions of 59 percent and 54 percent are also indicated.

Reductions required at other locations within the downtown can be estimated by reviewing the results of the APRAC analysis summarized in Table III-8. The accuracy of the estimates, based on comparisons with actual measured data, was discussed earlier in this section. The utility of the calculated carbon monoxide concentrations is that they provide an indication of potential problem locations; it is not implied that the values presented represent the absolute value of the highest concentration occurring at the various locations. Given that the estimates, for the most part, appear reasonable and in light of the absence of any measured air quality data for these locations, it was decided to use the second-highest calculated value from Table III-8 to indicate the need for air quality improvement at other downtown locations. Based on this, it can be seen from the table that there is an apparent need for reductions in carbon monoxide concentrations at several additional locations in downtown Springfield.

Hydrocarbons - Oxidant concentrations (measured as ozone) recorded in the AQCR indicated that the baseline value to be used for determining the required hydrocarbon emissions reduction was 0.134 ppm, recorded on 5 June 1973 for the hour ending at 1900 hours. The emissions reduction required, using linear rollback and based on the National Ambient Air Quality Standard of 0.08 ppm, is:

$$\frac{0.134 - 0.08}{0.134} \times 100 = 40.3\%$$

A 40.3 percent reduction represents a total of 38,914 kilograms per day, and implies that the total maximum allowable emission rate is 57,656 kilograms per day of reactive hydrocarbons.

For carbon monoxide, however, the compliance date for attaining reductions sufficient to meet the standards is 1 August 1976. Therefore, in order to establish the actual reduction required, the emissions concentrations expected as of (and beyond) 1 August 1976 must be considered. For oxidants, however, an extension to the original compliance date of 31 May 1975, has not been granted. In all probability, any extension granted would set the compliance date between 1 August 1976 and 31 May 1977. For purposes of this report, an attainment date of 1 August 1976 was assumed and required reductions in hydrocarbon emissions were computed based on this assumed date. Discussion of these future emissions is presented in the following text.

ESTIMATION OF FUTURE EMISSIONS AND AIR QUALITY

General

As mentioned in the previous section, it is essential to develop estimates of emissions for the future in order to determine the actual reduction in emissions necessary. These estimates can best be developed by analyzing past and present source characteristics as well as identifying and assessing factors which will have an influence on these source characteristics in the future.

Carbon Monoxide - Because automotive emissions contribute the greatest amount of carbon monoxide to the atmosphere it follows that estimates of future emissions must be based on automobile usage and emission characteristics.

Auto usage or vehicle-miles of travel (VMT) in downtown Springfield for present-day conditions was determined by data derived from the traffic study performed by GCA and from data routinely collected by the Springfield Traffic Engineering Department and the Massachusetts Department of Public Works. Attempts were made to develop projections of future VMT explicitely for downtown Springfield from available traffic volume data, however, reasonable trends could not be established because of various inconsistancies in the data and a lack of adequate long term or continuous count data. Therefore, projections of VMT in downtown Springfield were made based on growth rates for the Springfield-Chicopee-Holyoke Standard Metropolitan Statistical Area as determined by the Bureau of Transportation Planning and Development, Massachusetts Department of Public Works. Annual growth rates of 3 percent for 1974 through 1980, and 2.7 percent for 1980 through 1990 were determined. These rates were applied to interstate highways and major arterials only; volumes on other streets were assumed to remain constant throughout.

Table III-20. PROJECTED HIGHEST 8-HOUR AVERAGE CONCENTRATION OF CARBON MONOXIDE FOR 20 LOCATIONS IN SPRINGFIELD, MASSACHUSETTS

Location	1973 calculated[a] concentration (ppm)	Projected concentration - ppm[a,b]			
		1975	1976	1977	1980
1. State at Chestnut	6.75	5.88	5.00	4.34	2.58
2. State at Dwight	13.45	11.72	9.96	8.64	5.15
3. State at Main	12.63	11.01	9.35	8.12	4.83
4. W. Columbus at I-91 southbound off-ramp	9.87	8.60	7.31	6.34	3.78
5. W. Columbus at Memorial Bridge	9.61	8.37	7.12	6.17	3.68
6. W. Columbus at State	6.38	6.08	5.17	4.48	2.67
7. W. Columbus at Union	2.39	2.08	1.77	1.53	0.91
8. E. Columbus at Union	4.80	4.18	3.55	3.08	1.83
9. E. Columbus at State	8.57	7.47	6.35	5.51	3.28
10. E. Columbus at I-91 northbound on-ramp	8.06	7.02	5.97	5.18	3.08
11. E. Columbus at Vernon	10.89	9.49	8.06	7.00	4.17
12. E. Columbus at Worthington	5.88	5.12	4.35	3.78	2.25
13. E. Columbus at Liberty	1.95	1.70	1.44	1.25	0.74
14. Main at Hampden	6.03	5.25	4.46	3.87	2.30
15. Main at Hillman	18.21	15.87	13.49	11.70	6.97
16. Main at Vernon	16.78	14.63	12.43	10.78	6.42
17. Main at Union	8.31	7.24	6.15	5.34	3.18
18. Dwight at Worthington	8.92	7.77	6.60	5.73	3.41
19. Dwight at Harrison	6.02	5.24	4.46	3.87	2.30
20. Chestnut at Bridge	4.59	4.00	3.40	2.95	1.75

[a] Representative of 31 December conditions

[b] Accounts for normal growth in VMT and the effect of FMVECP

The second factor that will affect carbon monoxide emissions in downtown Springfield is the Federal Motor Vehicle Emissions Control Program (FMVECP), which will be discussed in detail later in this report. Essentially, the result of the FMVECP is that newer vehicles emit less carbon monoxide per mile than earlier vehicles; therefore, since new vehicles are constantly replacing older vehicles in the total vehicle population, the effect is a reduction in the emissions rate of the vehicle population, with time.

The VMT growth factors and changing emission factors were applied to the APRAC results discussed previously to provide estimates of air quality for several years beyond the baseline year; the highest 8-hour average concentrations projected for each location is shown in Table III-20.

The actual reduction in carbon monoxide concentrations that must be achieved is somewhat smaller than the baseline reduction discussed earlier. Since the date shown in Table III-20 represents conditions as of the end of each year, the projected concentrations representing 1 August 1976 must be determined; a simple linear relationship between 1975 and 1976 concentrations can be assumed, therefore, at the Main Street at Hillman Street location, the 1 August 1976 concentration is:

$$\left(\text{1975 concentration}\right) - \left(\text{1975 Concentration} - \text{1976 Concentration}\right)\left(\frac{7}{12}\right)$$

or,

$$(15.87) - (15.87 - 13.49)\ (0.583) = 14.48 \text{ ppm.}$$

As shown previously, the reduction would be:

$$R_{an} = \frac{C'_n - 9.0}{C'_n} \times 100$$

where R_{an} = The actual reduction required at location n by controls beyond FMVECP

C'_n = The projected 1 August 1976 concentration at location n

Again, for the Main Street at Hillman Street site, the actual reduction required beyond FMVECP is:

$$R_{an} = \frac{(14.48) - (9.0)}{(14.48)} \times 100 = 37.9\%$$

Hydrocarbons - It is appropriate to discuss hydrocarbon emission sources by major category; discussions of natural sources and transport from upwind sources are omitted.

Vehicular sources - As with carbon monoxide the major influences on emissions of hydrocarbons from vehicular sources are vehicle-miles of travel (VMT), and emission characteristics of the vehicle population.

Projections of growth in regional travel were developed from data provided by the Bureau of Transportation Planning and Development, Massachusetts Department of Public Works. These data consisted of VMT estimates by highway type for the Springfield-Chicopee-Holyoke Standard Metropolitan Statistical Area (SMSA) for the years 1974, 1980, and 1990. Summaries of the projected VMT for each county as well as the VMT distribution by roadway classification are shown in Table III-21 and with more detail, in Appendix H.

Hydrocarbon emission characteristics of the vehicle population will be affected by the FMVECP in a similar manner as carbon monoxide emissions. Emission factors have been developed to account for the different emission rates peculiar to specific model-year vehicles. In the computer program (VEHEMI-13) used to calculate emissions, these emission factors are reflected by the vehicle-age distribution for the particular year

Table III-21. SUMMARY OF TRAVEL PROJECTIONS FOR SELECTED YEARS THROUGH 1990: FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

County	Highway type	1973		1975		1976		1980		1990	
		DVMT	% of total	DVMT	% of total	DVMT	% of total	DVMT	% of total	DVMT	% of total
Franklin	Expressway	275,174	23.25	293,247	23.25	302,283	23.25	338,428	23.25	423,593	23.25
	Arterial, Collector	835,465	70.59	890,335	70.59	917,771	70.59	1,027,512	70.59	1,286,082	70.59
	Local	72,906	6.16	77,695	6.16	80,089	6.16	89,665	6.16	112,229	6.16
	Total	1,183,545	100.00	1,261,277	100.00	1,300,143	100.00	1,455,605	100.00	1,821,904	100.00
Hampden	Expressway	1,557,964	27.04	1,717,128	27.89	1,798,911	28.31	2,143,352	30.00	2,629,893	30.00
	Arterial, Collector	3,942,155	68.42	4,117,044	66.87	4,200,213	66.10	4,501,040	63.00	5,259,787	60.00
	Local	261,581	4.54	322,616	5.24	355,207	5.59	500,116	7.00	876,631	10.00
	Total	5,761,700	100.00	6,156,788	100.00	6,354,331	100.00	7,144,508	100.00	8,766,311	100.00
Hampshire	Expressway	157,020	10.27	180,694	11.06	192,899	11.44	246,461	13.00	314,040	13.50
	Arterial, Collector	1,260,134	82.42	1,323,507	81.01	1,354,169	80.31	1,469,290	77.50	1,721,401	74.00
	Local	111,764	7.31	129,557	7.93	139,110	8.25	180,107	9.50	290,777	12.50
	Total	1,528,918	100.00	1,633,758	100.00	1,686,178	100.00	1,895,858	100.00	2,326,218	100.00
Total	Expressway	1,990,158	23.49	2,191,069	24.21	2,304,093	24.64	2,728,241	25.99	3,367,526	26.08
	Arterial, Collector	6,037,754	71.25	6,330,886	69.94	6,472,153	69.22	6,997,842	66.67	8,267,270	64.01
	Local	446,251	5.26	529,868	5.85	574,406	6.14	769,880	7.34	1,279,637	9.91
	Total	8,474,163	100.00	9,051,823	100.00	9,350,652	100.00	10,495,971	100.00	12,914,433	100.00

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development; GCA/Technology Division estimates.

being analyzed. In estimating future emissions, the vehicle-age distribution was assumed to remain constant.

Using the projected growth in travel and taking into account the changes in emission factors, hydrocarbon emissions were calculated by the VEHEMI-13 computer model for 1974 through 1990; a summary of these emissions is shown in Table III-22.

Table III-22. PROJECTED HYDROCARBON EMISSIONS FROM VEHICULAR SOURCES FOR SELECTED YEARS: FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emission source	Projected emissions,[a] (kg/day)				
	1973	1975	1976	1980	1985
Light-duty vehicles	32,988	30,041	27,799	21,508	19,105
Light-duty trucks	8,887	7,910	7,556	5,625	4,701
Heavy-duty vehicles	7,729	6,749	6,435	4,967	3,632
Motorcycles	186	196	196	197	201
Light-duty diesel vehicles	4	4	4	5	5
Heavy-duty diesel vehicles	3,118	3,329	3,435	3,327	4,348
Total	52,912	48,229	45,425	35,629	31,992

[a] As of 31 December

Nonvehicular sources — As part of the Hydrocarbons Emissions Inventory (Volume II) mentioned previously, projections of hydrocarbon emissions through 1985 were developed for each category source. Table III-23 shows the growth factors determined in the inventory.

Table III-23. ANNUAL GROWTH RATES FOR NON-VEHICULAR HYDROCARBON EMISSIONS SOURCES IN FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Category	Annual growth rate (percent)
Dry cleaning	-1.5
Degreasing	2.5
Surface coating	2.5
Manufacturing	2.5
Bulk petroleum storage	-86.0 (1974-1975) -5.0 (1975-1985)
Fuel combustion	1.9
Solid waste incineration	0.7
Gasoline marketing	0.0 (1974-1975) -2.5 (1975-1985)
Aircraft, LTO's	6.0
Railroad and vessels	3.5

Source: Volume II

Emissions of reactive hydrocarbons from nonvehicular sources were then projected using the annual growth factors in Table III-23. A summary of the values computed for several years is shown in Table III-24.

Total hydrocarbon emissions - Again, it is appropriate to summarize the projected hydrocarbon emissions from the two major source categories considered; this summary is presented in Table III-25.

Actual Emissions Reduction Required - It was shown previously that the maximum allowable rate of emissions of reactive hydrocarbons is 57,656 kilograms per day which represents a required reduction from the baseline emission rate (96,570 kg/day for 1973) of 40.6 percent. Also, it was assumed that the compliance date for attaining a suitable reduction in emissions is 1 August 1976. Because the values for emissions shown in Table III-25 represent daily emissions as of 31 December for

Table III-24. PROJECTED REACTIVE HYDROCARBON EMISSIONS FROM NONVEHICULAR SOURCES, FRANKLIN, HAMPDEN, HAMPSHIRE COUNTIES

Emissions source	Projected emissions in kg/day[a]				
	1973	1975	1976	1980	1985
Dry cleaning	208	204	186	194	184
Degreasing	514	542	560	616	703
Surface coating	27,218	28,364	29,557	32,005	35,882
Manufacturing	2,732	2,871	2,943	3,248	3,673
Bulk petroleum storage	2,291	330	323	288	258
Fuel combustion	2,075	2,155	2,238	2,369	2,602
Solid waste incineration	793	803	808	833	862
Gasoline marketing	6,691	6,691	6,531	5,895	5,194
Aircraft LTO's	122	137	145	184	246
Railroad and vessels	1,014	1,086	1,123	1,290	1,531
Total	43,658	43,183	44,414	46,922	51,135

[a] Assumes no statutory controls applied

Source: Volume II

Table III-25. TOTAL PROJECTED AND REACTIVE HYDROCARBON EMISSIONS FROM ALL MAJOR SOURCES FOR SELECTED YEARS; FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emission source	Projected emissions, (kg/day)[c]				
	1973	1975	1976	1980	1985
Vehicular Sources[a]					
Light-duty vehicles	32,988	30,041	27,799	21,508	19,105
Light-duty trucks	8,887	7,910	7,556	5,625	4,701
Heavy-duty vehicles	7,729	6,749	6,435	4,967	3,632
Motorcycles	186	196	196	197	201
Light-duty diesel vehicles	4	4	4	5	5
Heavy-duty diesel vehicles	3,118	3,329	3,435	3,327	4,348
Subtotal	52,912	48,229	45,425	35,629	31,992
Nonvehicular Sources[b]					
Dry cleaning	208	204	186	194	184
Degreasing	514	542	560	616	703
Surface coating	27,218	28,364	29,557	32,005	35,882
Manufacturing	2,732	2,871	2,943	3,248	3,673
Bulk petroleum storage	2,291	330	323	288	258
Fuel combustion	2,075	2,155	2,238	2,369	2,602
Solid waste incineration	793	803	808	833	862
Gasoline marketing	6,691	6,691	6,531	5,895	5,194
Aircraft LTO's	122	137	145	184	246
Railroad and vessels	1,014	1,086	1,123	1,290	1,531
Subtotal	43,658	43,183	44,414	46,922	51,135
Total	96,570	91,412	89,839	82,551	83,127

[a] Assumes FMVECP in effect only.

[b] Assumes no statutory controls applied.

[c] As of 31 December.

each year, the theoretical 1 August emission rate must be derived by interpolation (assume 1 August emissions are equal to 1975 emissions plus 7/12th of the difference between 1975 and 1976 emissions). Table III-26 shows the calculated 1 August 1976 reactive hydrocarbon emissions for the three-county region. Because the 1 August emissions rate (90,500 kg/day) exceeds the allowable emissions rate (57,700 kg/day) then it can be expected that measures will be required beyond the FMVECP and existing nonvehicular source controls. These additional controls must be designed to achieve a reduction of at least 32,800 kg/day (90,500 kg/day - 57,700 kg/day) or 36.4 percent reduction in projected 1 August 1976 emissions. (The implications of choosing an alternative compliance date are discussed in Section V.)

Table III-26. PROJECTED REACTIVE HYDROCARBON EMISSIONS BY SOURCE AS OF 1 AUGUST 1976 FOR FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emissions source category	Emissions source	1 August 1976 emissions kg/day	% of total
Vehicular sources[a]	Light-duty vehicles	28,733	31.8
	Light-duty trucks	7,704	8.5
	Heavy-duty vehicles	6,566	7.3
	Motorcycles	196	0.2
	Light-duty diesel vehicles	4	Insignificant
	Heavy-duty diesel vehicles	3,391	3.7
Subtotal		46,594	51.5
Nonvehicular sources[b]	Dry cleaning	194	0.2
	Degreasing	552	0.6
	Surface coating	29,060	32.1
	Manufacturing	2,913	3.2
	Bulk petroleum storage	326	0.4
	Fuel combustion	2,203	2.4
	Solid waste incineration	806	0.9
	Gasoline marketing	6,598	7.3
	Aircraft, LTO's	142	0.2
	Railroad and vessels	1,108	1.2
Subtotal		43,902	48.5
Natural sources	Considered insignificant	-	-
Subtotal		-	-
Transport from upwind sources	Not determined	-	-
Subtotal		-	-
Total		90,496	100.0
Or, approximately		90,500	

[a] Assumes FMVECP only

[b] Assumes no statutory controls applied

REFERENCES

1. Kircher, David S. and Donald P. Armstrong. An Interim Report on Motor Vehicle Emission Estimation. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 27711. Publication Number EPA-450/2-73-003. October 1973. 38 pp.

2. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 27711. Publication Number AP-42. April 1973 (Second Edition). pp. 3.1.1-1 to 3.3.2-2.

3. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 27711. Supplement No. 2 to Publication Number AP-42. September 1973.

4. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 27711. Supplement No. 5 (Draft) to Publication Number AP-42. October 1974.

5. Compilation of Air Pollutant Emission Factors. U.S. Environmental Protection Agency, Research Triangle Park, N. C. 27711. Supplement No. 1 (Draft) to Publication Number AP-42. October 1974.

6. Technical Evaluation of the Metropolitan Boston Intrastate Air Quality Control Region Transportation Control Plan. U.S. Environmental Protection Agency, Region I Office, Boston. February 19, 1975.

7. Mancuso, R. L. and F. L. Ludwig. Users Manual for the APRAC-1 Urban Diffusion Model Computer Program. Stanford Research Institute. 1972.

8. Investigation of Ozone and Ozone Precursors Concentrations at Non-Urban Locations in Eastern United States. U.S. Environmental Protection Agency. May 1974.

9. Air Quality Criteria for Photochemical Oxidants. U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C. Publication No. AP-63. March 1970.

10. Air Quality Criteria for Nitrogen Oxides. U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C. Publication No. AP-84. January 1971.

11. Elkers, B. and K. R. Wilson. Air Basin Pollution Response Function: The Weekend Effect. Submitted to Science. Undated.

12. Altshuller, A. P. Evaluation of Oxidant Results at CAMP Sites in the United States. J Air Pollut Control Assoc. 25(1):19, January 1975.

13. Bell Laboratories. Statistical Analysis and Phenome-ological Interpretation.of the Atmosphere in the New York-New Jersey Metropolitan Region. Interim Status Report. May 1974.

14. Cleveland, W. S., T. E. Graedel, B. Kleiner, and J. Q. Warner. Sunday and Workday Variations in Photochemical Air Pollutants in New Jersey and New York. Sci. 186:1037, December 1974.

15. Stasirek, W. N. and P. E. Coffey. Rursl and Urban Ozone Relationships in New York State. J Air Pollut Control Assoc. 24(6);565, June 1974.

16. Coffey, P. E. and W. N. Stasirek. Evidence of Atmospheric Transport of Ozone into Urban Areas. Environ Sci Technol. 9(1):59, Jaunary 1975.

17. Power Plant Gases Source of Puzzling Rural Ozone Clouds. Science News. 106:260, Undated.

18. Schuck, E. A., A. P. Altshuler, D. S. Barth, and G. B. Morgan. Relationship of Hydrocarbons to Oxidants in Ambient Atmospheres. J Air Pollut Control Assoc. 20(5):297, May 1970.

19. Minott, David H. New England Consortium on Environmental Protection. An Investigation of the Air Pollution Meteorology of Western Massachusetts. For: Pioneer Valley Air Pollution Control District, Springfield, Mass. August 29, 1974.

SECTION IV

ANALYSIS OF INDIVIDUAL CONTROL MEASURES

GENERAL

Section Content

Section III of this report focused on defining and dimensioning the air quality problems that exist in the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region (AQCR). Given the analysis of air quality problems provided in Section III, the need for control measures on emission sources became obvious. It is the purpose of this section to discuss and assess individual control measures that have been developed to reduce pollutant emissions and, consequently, improve ambient air quality throughout the Massachusetts portion of the AQCR.

Following the introductory material, each proposed control measure will be separately discussed. The first control measure to be discussed is the Federal Motor Vehicle Emissions Control Program (FMVECP), which is not a control measure in the strict sense because it is being implemented outside of the TCP framework but an important measure to review because of its impact. Following the FMVECP discussion will be an analysis of each of the measures proposed to be included in the TCP. For each measure, information is presented on its effects on transportation and air quality, and on its social, economic, and institutional effects. Separate discussions are presented for the entire Massachusetts portion of the AQCR and for the Springfield CBD, where appropriate.

The discussion in this section focuses on strategies as individual entities; assessment of the impact of combined control measures will be presented in Section V.

The remainder of this introductory material presents a description of the general methodology for analysis of the proposed transportation control measures. A more detailed discussion of the assumptions and method of analysis for each element in the strategy package is included in the appropriate portion of this section that discusses the specifics of each strategy.

Evaluation Methodology

Measures Evaluated - This transportation control strategy package has been developed in conjunction with the U.S. Environmental Protection Agency, City of Springfield, Massachusetts Department of Public Works, Massachusetts Department of Environmental Quality Engineering,* and several other State, local, and regional agencies. The elements of the package, in the order in which they will be discussed in this section, are:

1. Federal Motor Vehicle Emissions Control Program (FMVECP)
2. Stationary (nonvehicular) source controls
3. State carpool program
4. Mass transit improvements
5. Traffic flow improvements
6. Inspection and maintenance of light-duty vehicles

Methodology to Evaluate the Impact of Measures on Travel and Traffic Flow Characteristics - Three of the six measures evaluated in this report (Items 3, 4, and 5 in the list above) are expected to affect either traffic flow patterns in Springfield or regionwide travel volumes, or both. For these three measures, transportation engineering studies were performed in order to provide the data needed for estimating the effect of these measures on emissions and air quality.

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*Formerly the Bureau of Air Quality Control

Mass transit improvements and the state carpool program were analyzed for their effect on regionwide travel by estimating the number of trips, length of trips, and thus vehicle-miles of travel that would be affected.

Traffic flow improvements are proposed for the Springfield Central Business District only. Detailed traffic assignment procedures, using data obtained through a special traffic study performed by GCA for this report, were utilized for determining the effect of each alternative improvement on travel volumes and speeds on each street in the Springfield CBD. This process was used only for evaluation of the carbon monoxide problems in the CBD.

Methodology to Evaluate the Impact of the Measures on Vehicle Emissions and Air Quality - Section III described the use of two computer programs for determining vehicular emissions and their impact on air quality. The transportation controls that affected regionwide emissions of hydrocarbons were evaluated by using VEHEMI 13, which computed the changes in total emissions as a result of the changes in VMT, speed, or emission factors determined for each control measure. Traffic flow improvements in the Springfield CBD were evaluated for their impact on CO concentrations through the use of APRAC, which calculates concentrations of carbon monoxide at specific locations, using information on emission factors and on traffic density and speed determined from transportation engineering studies as described above. These procedures were described in general in Section III and will be further elaborated upon in connection with the analysis of each measure below.

Methodology to Evaluate the Impact of the Strategy Package on Social, Economic, and Institutional Factors - The necessity of a social and economic analysis of the control measures resides in the fact that undesirable tradeoffs between improvements in air quality and changes in the social and economic fabric of a community are to be avoided where possible. This type of analysis aids in the decision-making process by adding another dimension to the inputs considered.

In order to facilitate understanding of this analysis, a few comments are in order. First, GCA has attempted to separate the social impacts from the economic impacts. Although it is acknowledged that this is often a difficult distinction to perceive, it is considered that the segregation is beneficial in terms of understanding the issues. Under social impacts GCA has included the advantages and disadvantages - pecuniary and nonpecuniary - that affect residents as individuals. Thus, any changes in prices, taxes, or mandatory expenditures along with subjective changes in lifestyle are included under social impacts. Economic impacts refer to the effects, mainly pecuniary, which affect the State or business establishments as legal entities. The types of cost most often referred to under economic impacts are capital costs and annualized costs. Capital costs are defined as those expenditures for plant and equipment. Annualized costs are those expenditures associated with the yearly operation and maintenance (including depreciation) of the capital equipment.

Secondly, it is important to note that the quantification of costs and benefits was not possible in every instance. This is due either to lack of information or, more basically, to the fact that certain items are not allocated by the market mechanism and hence lack an assigned monetary value. In those instances where quantification was not possible or reasonable, qualitative assessments are presented. Thus, even though all significant parameters are not quantified, they are identified.

Finally, it should be emphasized that the figures presented represent the best possible estimates. It is nevertheless important to bear in mind that the magnitudes are subject to change in the future for a variety of reasons. Paramount among these reasons is the fact that, given the formative nature of several of the measures, changes in the exact nature of the measures may take place.

The discussion of legal and administrative effects deals with the institutional requirements of measure implementation and operation. Legal issues include the identification of legal authority necessary for implementation as well as any post-implementation legal problems that may arise. The identification of the groups necessary for measure implementation as well as the type of coordination needed among the involved bodies is discussed under administrative effects.

FEDERAL MOTOR VEHICLE EMISSIONS CONTROL PROGRAM (FMVECP)

General

Description - The Federal Motor Vehicle Emissions Control Program (FMVECP) is the national program that requires new motor vehicles to meet certain standards for exhaust emissions. The major statutory basis for the program in its present form is the Clean Air Act of 1970, although later legislation has modified the FMVECP several times. The Federal government began setting emission standards for automobiles with the 1968 model year. Thus, the FMVECP has been in operation for several years and is familiar to most Americans.

The FMVECP regulates the emissions from new cars and engines made in the United States or that are imported into this country. Manufacturers are required to obtain certification from EPA that their cars and trucks meet specified emission standards set by EPA. Therefore, it is possible to quantitatively predict the emissions of a population of automobiles, given their model years and knowledge of the applicable emission standards.

The FMVECP is thus implicitly assumed to operate throughout the period of time for which this study was done, even though it is not a State program and not literally a control strategy. The chief importance of the FMVECP is that the stricter emission standards applicable to later model year vehicles imply that emission rates (grams per mile) from the vehicle population in the Springfield area will decline as older vehicles are replaced by newer ones, all other things begin equal. The discussion to follow will show the effect of the FMVECP on emissions, as though it were a separable strategy, for information purposes.

Assumptions - This report is based upon analysis of the FMVECP using emission rates specified for such purposes by EPA, as explained in Section III. There is, however, some uncertainty about the emission standards that will be in effect for the 1978 and later model year vehicles. The various emission factors used in this report take into account the 1-year extension of the interim exhaust emission standards to include model year 1977, as announced by EPA on March 5, 1975. But, the President has proposed, and the Administrator of EPA has recommended, further relaxations of the current statutory emission standards for light-duty motor vehicles (LDV). In order to obtain an evaluation of the probable impact of such a relaxation of standards on the expected air quality in the cities of New England and on the efforts to develop, implement, and enforce implementation plans including transportation control plans (TCP's), a special computer run was made using hydrocarbon emission indices modified to reflect a 5-year extension of the present interim standards as one possible course to be followed when the Congress acts on the recent advice from the President and the Administrator of EPA. The results were presented in the GCA report on the Connecticut transportation control plan.[1] The net result was that there is no effect in 1976 and only a small effect in 1977, since that year's expected emission rate has already been increased materially by the EPA announcement of March 5, 1975. For the years beyond, however, the effect is considerable, averaging around 25 percent of the baseline values - those which would have been realized without any additional extensions of the standards.

Social and Economic Impacts - No analysis was done of the social or economic impacts on the State of the FMVECP, because this is a Federal program and neither optional nor peculiar to Massachusetts. Limited information is available on the national economic implications of the FMVECP and similar automotive emission controls.[2]

Effectiveness in the Springfield Study Area

Carbon Monoxide - To determine the effect of the FMVECP on CO emissions, a special computer run was made with the VEHEMI-13 computer program. The program was used to calculate emissions for a hypothetical area using a vehicle-age distribution characteristic of downtown Springfield and assumed value for vehicle-miles of travel, average vehicle speeds, and distribution by highway facility; these input data were held constant while total emissions for different base years were calculated. The results of this analysis are shown in Figure IV-1.

The analysis shows that FMVECP alone will reduce CO emissions rates (i.e., emissions for a fixed amount of travel) by 18.4 percent below the 1973 baseline in 1975* and by 33.0 percent below the 1973 baseline in 1976.* These are theoretical reductions, however, since vehicle-miles of travel (VMT) will increase with time. The impact of FMVECP on emissions from the projected traffic can best be seen in Table III-20, presented in Section III.

Hydrocarbons - Hydrocarbon emissions will be reduced in a manner similar to that shown for carbon monoxide. The actual expected reduction with time was shown in Table III-22. Again, this table shows

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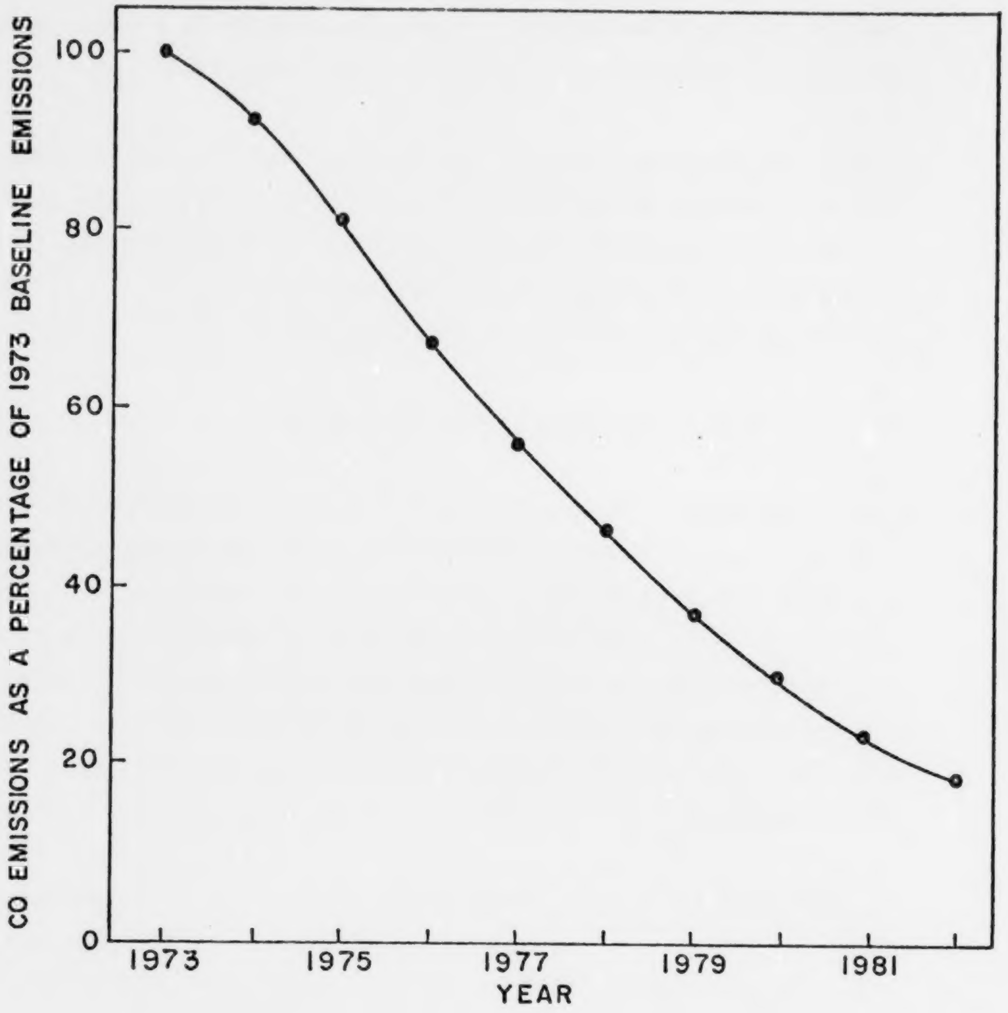
*As of 31 December for each year.



NOTE: BASED UPON FIXED VMT, SPEEDS, AND VEHICLE AGE DISTRIBUTIONS. NET RESULT IS TO SHOW EFFECT OF FMVECP, ALONE.

Figure IV-1. Effectiveness of FMVECP on reducing emissions of carbon monoxide in downtown Springfield, Massachusetts

automotive emissions for the entire AQCR for various years through 1985, taking into account changes in travel (VMT), changes in VMT distribution by highway type, as well as changes in emission factors resulting from FMVECP. Figure IV-2 shows this change in hydrocarbon emissions from vehicular sources with respect to time (including growth in VMT and changes in emission factors, etc.).

STATIONARY (NONVEHICULAR) SOURCE CONTROLS

Description

Many commercial and industrial processes and nonvehicular mobile sources produce hydrocarbon emissions that contribute to the total hydrocarbons/oxidants problem. Most of these nonvehicular sources are amenable to certain types of emission control devices or procedures. For this study it was assumed that additional source controls will be implemented on nonvehicular sources.

The description of the proposed controls and their applicability to particular types of sources are presented in Volume II. Regulations to implement the proposed controls are presented in Appendix A of Volume II, and are assumed to be the same as for the Boston Intrastate AQCR. A summary of Volume II is in Appendix G of this volume.

Effectiveness

Volume II also analyzed the effectiveness of the proposed controls. It was concluded there that photochemically reactive hydrocarbon emissions from nonvehicular sources in the Springfield AQSA would be 74 percent lower with controls in 1975 than without. By the attainment date, in 1976, the proposed controls would reduce baseline (1973) nonvehicular reactive emissions by 73 percent. In 1976 this would amount to a reduction in the total (vehicular and nonvehicular)

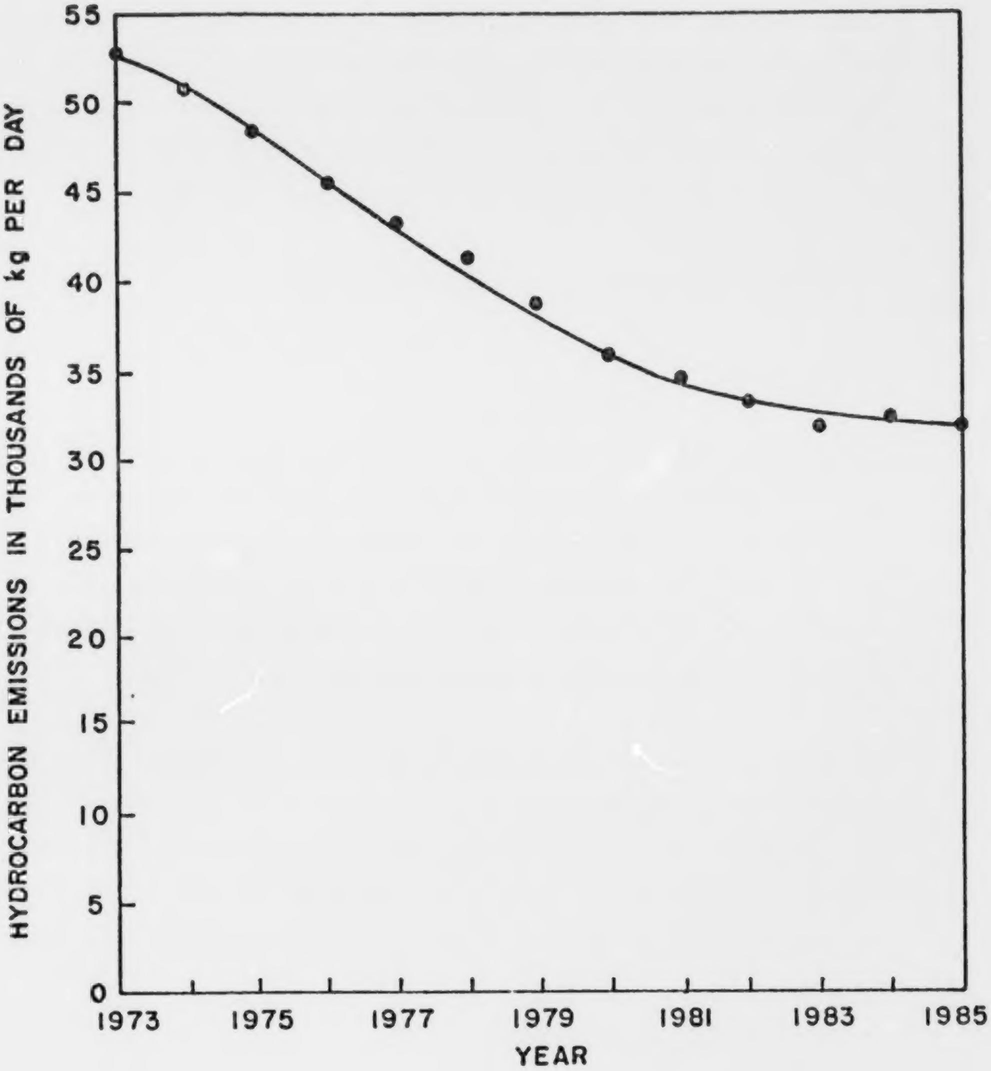


Figure IV-2. Changes in hydrocarbon emissions from vehicular sources with respect to time, accounting for changes in travel characteristics and emission factors as well; Franklin, Hamden, Hampshire Counties

baseline (1973) reactive HC emissions by 33 percent. Total projected nonvehicular reactive HC emissions are summarized in Table IV-1.

Table IV-1. SUMMARY OF EFFECTIVENESS OF CONTROLS ON NONVEHICULAR SOURCES OF HYDROCARBONS IN SPRINGFIELD AQSA

	Emissions of reactive hydrocarbons by nonvehicular sources in Springfield AQSA, kg/day[a,b]				
	1973[c]	1974[d]	1975[d]	1976[c,e]	1977[d]
Without controls	43,900	44,500	43,200	43,900	44,300
With controls[f]	--	--	11,100	11,900	13,900

[a] Data presented in units of kg/day to be consistent with other data in this volume. For comparison with Volume II, 1 kg/day = 0.40 tons/year.

[b] All figures rounded to nearest 100 kg/day.

[c] Interpolated from figures in Volume II.

[d] Source: Volume II.

[e] 1976 figure for 1 August 1976 (attainment date); others assumed to apply at year end.

[f] Controls are as described in Volume II.

Social Impacts

The primary social impact associated with the HC regulations and stationary sources will be any price increases resulting with the increased business costs created by the controls. It is not possible to estimate these given the existing amount of information. The most visible impact, however, is likely to be gasoline price increases.

Economic Impacts

The imposition of HC regulations on stationary sources could be expected to create a wide range of economic impacts depending upon the nature of the regulation and the size of the firm complying with the regulation. The discussion below is organized according to industry type and refers extensively to Volume II of this report, "Hydrocarbon Emission Sources in the Springfield, Massachusetts Area."

Dry Cleaning - The tacit assumption used in the HC emission inventory is that while total HC emissions from these sources won't decline, the reactive HC emissions will approach zero. This is due to the fact that no reactive solvents will be used. To achieve this, an establishment presently using a "Stoddard" solvent which is reactive will either have to switch to a nonreactive form of "Stoddard" or start utilizing perchloroethylene ("perc"). If reactive "Stoddard" is replaced by a nonreactive "Stoddard," no major economic problems will ensue given the insignificant price differential between the two.

Degreasing - Degreasing establishments in most cases should not find it necessary to purchase control equipment but will instead reformulate - switch from reactive to nonreactive solvents. Only perchloroethylene or saturated halogenated hydrocarbons would be used. Firms that, for particular reasons, chose to use control equipment will incur capital costs. No estimates of such costs are provided here. Others may also incur modest cost increases for nonreactive solvents.

Surface Coating - Industries falling under this general category will most likely reformulate. Again, increased solvent cost would be the only significant economic impact.

Manufacturing - The control options for this sector will be likely to involve some form of control equipment. Volume II discusses the control options and their costs. Small and medium size establishments will bear a greater relative impact.

Bulk Petroleum - Controls for petroleum products emissions are of two types - controls for transferring and controls for storing the materials.

No cost estimates are available for the transfer controls. However, estimates do exist for the controls for storing. While recovery systems are available for fixed roof tanks, it is more economical to convert fixed roofs to floating roofs by installation of internal floating covers. Example costs are given in Table IV-2 below.

Table IV-2. ESTIMATED INSTALLED COSTS OF GASOLINE STORAGE TANKS[4]

Nominal tank capacity	50,000 barrels	100,000 barrels	150,000 barrels
Size	90' dia x 48'	120' dia x 48'	150' dia x 48'
Installed costs			
Fixed roof tank	$161,000	$257,000	$379,000
Pontoon floating roof tank	$176,000	$279,000	$403,000
Internal floating cover in existing roof tank	$34,000	$54,000	$68,000

Gasoline Marketing - To achieve a 90-percent reduction in HC emissions from gasoline stations requires controls at gasoline service stations. This in turn requires vapor recovery during tank truck loading at bulk plants and terminals. The most feasible approach is as follows:[3]

Phase I (55 percent control - short range)

1. Modify tank trucks and install the necessary equipment at service stations to recycle the vapors displaced from the underground storage tanks back to the tank trucks during gasoline delivery.
2. Install vapor recovery systems to collect and recover the vapors collected at the service station, as they are displaced from the tank truck during reloading at bulk plants and terminals.

Phase II (35 percent control - long range)

1. Install special gasoline dispensing nozzles, hoses and vapor return lines on the gasoline pumps at the service stations to collect and return vapors displaced from the automobile fuel tank during refueling, to the underground storage tanks at the service station.
2. Install vapor recovery equipment on the underground storage tanks at the service station if necessary, to achieve an overall reduction in emissions of 90 percent at the service station.

The costs associated with these two phases are presented in Table IV-3.

Table IV-3. HC CONTROL COSTS PER SERVICE STATION DISPENSING 25,000 GALLONS OF GASOLINE PER MONTH[4]

	Carbon canister	Refrigeration-condensation
Investment ($)	7,946	14,535
Annual cost		
($/yr)	1,465	2,860
($/lb recovered)	0.24	0.48
(¢/gal pumped)	0.48	0.95

Source: Environmental Protection Agency. Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources

Legal and Administrative Issues

It is likely that the implementation of these regulations will involve moderate to significant administrative complications. The major reason for this will be the monitoring of the sources. At a minimum, some form of reporting by firms to the State must be established. This would involve expenditures of effort by the firms completing the form as well as the cognizant State agency processing the forms. In addition, it may be necessary to make spot checks on establishments coming under the regulations. This would involve an even greater expenditure of manpower on the part of the State.

Additional administrative and legal issues cannot be identified at this time given the preliminary nature of the proposed regulations. Proposed regulations are presented in Appendix A of Volume II.

STATE CARPOOL PROGRAM

Description

The Massachusetts Executive Office of Transportation and Construction (EOTC) is supervising the development of a program to encourage carpooling and other actions to increase the use of multiple-occupant vehicles (including transit). This program is intended primarily for implementation by employers. EOTC has arranged for the preparation of an instruction manual for employers to use in organizing their own carpool plans, vanpools, or othe action elements, and EOTC has also arranged for their consultants to provide direct assistance to the employers. Also, the Massachusetts Department of Public Works will make available a computer code for matching the names and travel patterns of prospective carpoolers, to assist employers in making arrangements for carpools among their employees.

The draft of this report identified the EOTC employer incentive program as a probable element of the TCP for the Springfield area and briefly reviewed its potential. At that time, no detailed analysis was presented because the details were not yet known. Since then, further details of the carpooling/employer incentive program, as it would apply to the Springfield area, have been identified. Appendix K of this report provides a special new analysis of the carpooling element of the EOTC program as it would be applied to the Springfield area.

Effectiveness

Effectiveness of the expected format of the EOTC employer incentive/carpool program is presented in Appendix K. Its effectiveness in combination with other measures is discussed in Section V.

Social and Economic Impacts

The EOTC carpool program for Springfield was not defined in time for a detailed study of the social and economic impacts. Qualitatively, the primary social impacts will be reduced gasoline consumption and reduced travel costs for the individuals involved. The collective economic impact will be the cost of establishing and operating the program, which will vary considerably according to what program elements or incentives are provided by each employer. (See also Section V).

Legal and Administrative Issues

There do not appear to be any substantial legal issues associated with a statewide carpooling program. The sponsoring agency is not held to a standard of care to investigate questions relating to safety and security of carpool participants in any case where, as sponsor, it organizes and administers a voluntary carpooling program in which driver and passenger with common transportation interests are identified and matched but are not assigned or in any way compelled by the sponsor to participate.[6]

Responsibility for administration will be divided among the employers, EOTC, and the consultants. Administrative arrangements in the Springfield area are expected to be similar to those in the Boston area.[5]

MASS TRANSIT IMPROVEMENTS

Description

The existing transit system in the Springfield-Chicopee-Holyoke region was the subject of a recent comprehensive transit planning study[7] for the Lower Pioneer Valley Regional Planning Commission. The stated objectives of the study were: (1) identify the nature, problems, and potentials of existing transit services; (2) assess the needs for public transportation as reflected by existing service patterns and community interest groups; (3) identify basic transit improvement options; and (4) develop a short range transit improvement plan. Of particular interest here is the fourth objective - the short range transit improvement plan. The short range plan was used as the basis for development of transit strategies discussed in this report.

Many of the transit system improvements being discussed here are, at present, only proposals. Their final form may be different. Nonetheless, these proposals were evaluated for their potential to improve air quality, with the expectation that the transit improvements finally implemented will provide roughly comparable service and thus comparable impacts on air quality. There is no intention here to rigidly specify the exact transit improvements to be undertaken.

Inasmuch as the transit plan referred to above is of a very comprehensive nature, effort will not be expended here in transcribing detailed data contained therein; however, the major recommendations for immediate action transit improvements described in the report will be outlined here. In general, the plan addresses the following issues: (1) Transit district management structure, (2) route and service revisions, (3) bus fleet modernization, and (4) improved passenger amenities.

Several elements of the first issued have already been actualized - most notably, the formation of the Lower Pioneer Valley Transit Authority. This is seen as the first step in a serious effort to upgrade bus transit in the region. Other measures will be regarded as mass transit improvement strategies to be included in the Transportation Control Plan or implemented in parallel with the TCP; these are outlined in the following paragraphs.

Service Improvements - The transit plan identifies various bus services that should be provided to the region. These recommended services are seen as being within the capabilities of existing carriers and could be implemented within existing franchises. Coordination by the Regional Transit Authority is requires. The plan[7] provides initial estimates of equipment requirements, headways, and bus-miles of travel for the recommended route system. Highlights of the proposed improvements are outlined below.

Express service - There are currently six express bus routes serving the region. The plan calls for retaining the existing express service but suggests that trip frequency be increased on several of the routes. Four new express routes are also proposed - these would link Springfield with Ludlow, the Enfield shopping malls, and Westfield.

In addition, park-and-ride facilities are recommended at the Eastfield Mall, the Fairfield Mall, Page Boulevard at I-291, and at existing parking facilities in the vicinity of the Allen Street-Coley Street intersection in Springfield. The existing and proposed express routes and their relationship to the proposed park-and-ride facilities are summarized in Table IV-4.

Regional routings - The report developed guidelines for revising bus routes to be more responsive to the travel needs of the public. Specific recommendations are as follows:

1. Springfield route revisions

Changes are recommended in Routes 1 and 4 to reflect redevelopment on Route 1, and to improve access from the south to the Springfield Hospital Medical Center. Compensating changes are suggested in Routes 3 and 5 to preserve no-transfer travel between Main Street south of Carew and State Street west of Hancock, and to provide no-transfer riding from the Forest Park neighborhood via Dickinson to the Springfield Plaza and Fairfield Mall shopping centers. The Ludlow and Westfield local services would also be linked for better distribution within downtown Springfield. Also Route 8 (Walnut-Plumtree), is suggested for restructuring into two through routes. One of these would operate via Main and Vernon, Memorial Bridge and Main Street in West Springfield to Amostown Road near the West Springfield High School. Ultimately, if ridership and land use policies require, this route might extend to Brookside Drive in West Springfield.

The other route would operate from Springfield College via Walnut and State to Main and Liberty, and then would run express (via I-291, if possible) to and from a park-and-ride station at Springfield Plaza.

2. Holyoke route revisions

The plan recommends a bus route arrangement which links present routes to provide through service on a consistent basis. For example, it suggests that South Hadley Center buses (present Holyoke Route 6) run through to Elmwood-Oakdale (present Holyoke Route 16). South Hadley Falls buses would be linked with the proposed Highlands Loop (planned Route 37). Oakdale-West Glen buses (present Holyoke Route 15) would run through to Bridge Street to improve service to the Model Cities Area. In addition, Westover buses (planned Route 35) could operate through to Holyoke Community College off-peak, and Highland Park (planned Route 41) buses could operate through to East and Roosevelt (planned Route 33) in the peaks and Whiting Farms (planned Route 43) off-peak.

The plan further proposes that the Holyoke-Northampton service be routed entirely via Easthampton, replacing the lightly patronized portion of present Holyoke Route 12 on U.S. 5. An extension of the planned Highland Park rout (41) to Mountain Park is recommended for Saturdays and summer periods when idle buses will be available. A turnback service between Holyoke and Easthampton (proposed Route 39) timed to connect with the Easthampton-Northampton schedules of the Western Massachusetts Bus Lines, is also recommended.

Table IV-4. SUMMARY OF PROPOSED EXPRESS BUS SERVICES

Route name	Central terminal	Outer terminal	Local pickup route	Express route	Downtown distribution	Suggested time of operation	Estimated terminal-to-terminal running time	Route status	Proposed park and ride facility sites	Intended purpose of route	Suggested fares	Estimated weekday ridership
Hampden Express, Route 27	Springfield Bus Terminal	Scantic Road, Hampden (turnback service to Allen and Porter Road in peaks)	Main Street (Hampden), Allen Street to Sumner Avenue	Sumner, Columbus to downtown	Columbus, State, Main Street bus mall to terminal	All day	35 minutes	Part of Peter Pan System	Sixteen Acres (Allen and Cooley Sts.)	Access to downtown Springfield; access to shopping center and junior high school from inner city	60 cents; 45 cents (within Springfield; 35 cents (within Hampden, East Longmeadow)	120 passengers (1975)
Enfield Express via I-91, Route 26	Springfield Bus Terminal	Enfield Mall, State Line Plaza	Park and ride stops in shopping centers	I-91 to downtown	Columbus, State, Main Street bus mall to terminal	6:00 to 9:00 a.m., 3:00 to 6:00 p.m.	20 minutes	New route	Enfield Mall, State Line Plaza	Access to downtown Springfield; access to shopping center jobs for innercity residents	60 cents (non-stop shuttle service	100 passengers (1975)
Enfield Express via Longmeadow, Route 25	Springfield Bus Terminal	Thompsonville, Enfield	Within Conn., Longmeadow St. to I-91 interchange	I-91 to downtown	Columbus Avenue, State Street to Main, Main Street bus mall to terminal	All day	30 minutes	Part of Longueil System	Not established	Access to downtown Springfield from Longmeadow; access to Enfield employment centers from Springfield; access to Baypath Jr. College; access to innercity residents to Longmeadow domestic employment	60 cents; 35 cents (within Connecticut); 25 cents (within Longmeadow); 50 cents (Longmeadow-Springfield)	300 passengers (1975)
East Longmeadow Express, Route 24	Springfield Bus Terminal	Hampden Road and Parker Street, East Longmeadow	Hampden Road, Parker Street, Somers Road, North Main Street to Dwight Road	Belmont to Main, Main to State (May stop on request for through passengers.)	Main Street bus mall to terminal	All day	25 minutes	Part of Longueil System	Main Street, East Longmeadow	Access to downtown Springfield	50 cents; 35 cents (within East Longmeadow)	200 passengers (1975)
Wilbraham Express, Route 23	Springfield Bus Terminal	North Wilbraham Green (via North Main Street)	North Main St., Wilbraham Rd. to Truman Circle	Wilbraham Rd., State Street (May stop on request for through passengers.)	Main Street bus mall to terminal	All day	40 minutes	Part of Longueil System	Not established	Access to downtown Springfield from Wilbraham and N.E. College; access to Western N.E. College	60 cents; 35 cents (for local rides)	360 passengers (1975)
Eastfield Express via Parker, Route 22	Springfield Bus Terminal	Eastfield Mall (via Parker Street)	Parker Street, Wilbraham Rd., Plumtree Road, Bradley Rd., Wilbraham Rd. to Truman Circle	Wilbraham Rd., State Street (May stop on request for through passengers.)	Main Street bus mall to terminal	All day	35 minutes	Part of Longueil System	Eastfield Mall or Springdale Shopping Centers	Access to downtown Springfield from suburban area, including apartments along Parker Street; access for innercity residents to Western N.E. College and shopping center employment	50 cents; 35 cents (for local rides)	400 passengers (1975)
Mount Holyoke Express, Route 20	Court Street, Springfield	Mount Holyoke College, South Hadley	Route 33 to Mass. Turnpike Interchange, via Westover on Request	Fuller Road to I-291, I-291 to Chestnut Ramp	Main Street bus mall to Court Street	All day	40 minutes	Part of Peter Pan System	South Hadley, Fairfield Shopping Centers	Access to downtown Springfield; access for innercity residents to shopping center, motel, and college employment	75 cents; 60 cents (between Chicopee and Springfield)	320 passengers (1975)

Table IV-4 (Continued). SUMMARY OF PROPOSED EXPRESS BUS SERVICES

Route name	Central terminal	Outer terminal	Local pickup route	Express route	Downtown distribution	Suggested time of operation	Estimated terminal-to-terminal running time	Route status	Proposed park and ride facility sites	Intended purpose of route	Suggested fares	Estimated weekday ridership
North Wilbraham Express, Route 12	Springfield Bus Terminal	North Wilbraham Green (via U.S. 20)	Boston Road to Bay Street	State Street (May stop on request for through passengers.)	State Street and Main Street bus mall to terminal	All day	25 minutes	Part of Peter Pan System	Eastfield Mall or Springdale Shopping Centers	Access to downtown Springfield; access for innercity residents to shopping center employment	65 cents; 50 cents (within Springfield)	320 passengers (1975)
Westfield Express, Route 10	Springfield Bus Terminal	Noble Hospital, Westfield	Court Street, Silver Street, Pleasant Street, North Elm Street to Mass. Turnpike Interchange	Massachusetts Turnpike to I-291, I-291 to downtown	Vernon Street, Main Street bus mall to terminal	6:00 to 9:00 a.m., 3:00 to 6:00 p.m., 10:00 to 12:00 p.m.	25 minutes	New route	Not established	Access to industries in Westfield; access to downtown Springfield; access to Noble Hospital in Westfield	75 cents; 35 cents (within Westfield)	250 passengers (1975)
Ludlow Express, Route 9	Court Street, Springfield	East Street at Williams, Ludlow	East Street, Ludlow; Parker Street, Page Boulevard to I-291 Interchange	I-291 to Chestnut, Chuesnut to Liberty, Liberty to Main	Main Street bus mall to Court Street	a.m. and p.m. peaks. Late evening runs if industry access warrants	25 minutes	New, not presently operated	North side Page Boulevard near I-291 (present sandpit)	Access to downtown Springfield from Ludlow and Indian Orchard	60 cents (Ludlow-Springfield); 30 cents (Indian Orchard-downtown); 35 cents (Ludlow-Indian Orchard and other local trips)	240 passengers (1975)

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

New service - Several areas have been identified by the plan where new service is warranted; these are as follows:

1. Springfield crosstown service

   The plan recommends establishment of a route from White and State and Walnut, north along Armory to the I-291 interchange complex, north along Liberty to Newbury Street, and north along Newbury Street (which is not now served by public transportation) to Springfield Street in Chicopee. This suggested route terminates at Chicopee center, where it would connect with Routes 1, 4, and several Holyoke-oriented bus routes. It is estimated that approximately 300 passengers per day would initially use this route, assuming a typical traffic density for crosstown bus services.

2. Employment access routes

   The recommended plan would provide industrial access by proposed Routes 6 (Roosevelt-Monsanto), 72 and 73 (Milton Bradley-Package Machinery), and 74 (Worthington). Domestic employment access is provided by Route 71 (Laurel Street, Longmeadow). Proposed Routes 11 (Westfield-Springfield Express) and 44 (Holyoke-Westfield) would also improve access to outlying indistrial employment for inner city residents.

3. Five colleges bus service

   The plan recommends that an additional bus be added to the route connecting Smith College and the University of Massachusetts. This would provide 30-minute headways convenient for class changes at both institutions.

4. University of Massachusetts service

   The plan calls for continued operation of the University-area special buses with local support from both the University and the Town of Amherst. In addition, extensions into Hadley (Route 68) and South Amherst (Route 69) are recommended to serve high and medium-density housing developments.

Passenger Amenities - Numerous amenities are necessary to help generate and maintain public support and use of bus transit. The transit plan has identified several specific amenities that appear needed in the region.

Bus shelters - A number of specific locations have been identified where suitable bus shelters should be provided; these locations are given in Table IV-5.

Bus stop signs - A bus stop sign program should be instituted throughout the area. Bus stop signs should be of a distinctive logo, and should identify the location, the routes using the stop, and the destination or direction of each route.

Route maps and schedules - The plan recommends that large-scale route maps of the transit system in each transit district be published and made available to the public. Also, the plan suggests that route maps be printed on the corresponding timetable for that service.

Marketing strategy - It is recommended that each transit district undertake a program to market bus transit utilizing such enticements as:

- Promotional fare plans (dime-time, etc.)
- Prepaid pass systems
- Active public information programs

Traffic-Transit Integration - The plan also suggests measures to expedite transit service in downtown areas through traffic management techniques such as curb parking controls and exclusive bus lanes. The recommendations pertain mainly to downtown Springfield and will be discussed in the Traffic Flow Improvements part of this section.

Effectiveness

The short-range transit plan, on which the strategies above were based, calls for implementation of the improvements over a 5-year period. Although several of the recommendations will be implemented

Table IV-5. RECOMMENDED BUS SHELTER LOCATIONS

Facility	Location	Number of shelters
Convergence of Bus Routes	State Street and Main Street, Springfield	3
Convergence of Bus Routes	City Hall, Holyoke	1
Park and Ride Facility	Eastfield Mall adjacent to U.S. Route 20	1
Park and Ride Facility	Springfield Plaza adjacent to Liberty Street	1
Park and Ride Facility	Fairfield Plaza near Route 33	1
Park and Ride Facility	Near Allen and Cooley Streets in shopping center parking lot	1
Noble Hospital	Silver and Mill Streets, Westfield	1
Potential Transfer Point	Park between Main and Elm Streets, West Springfield	2
Potential Transfer Point	Bridge, Main, and Carew Streets, Springfield	4
Potential Transfer Point	Liberty and Carew Streets, Springfield	2
Potential Transfer Point	State and Federal Streets, Springfield	2
Mass. Mutual, City Hospital and High School	State and Alton Streets, Springfield	2
Springfield Hospital	Springfield and Chestnut Streets, Springfield	2
Potential Transfer Point	Wilbraham Road and Parker Street, Springfield	2
Park and Ride Facility	Shawingan Drive east of I-291, Chicopee	1
Potential Transfer Point	St. James Avenue and Carew Street, Springfield	2
Wesson Hospital, High Schools	State Street near School, Springfield	2
		Total 30

by July 1975, it is doubtful that the entire plan could possibly be actualized by the TCP compliance date of 1 August 1976. Therefore, in estimating the effectiveness of the strategy with respect to its contribution to obtaining the required reduction in pollutant concentrations, several assumptions have to be made with regard to the plan phasing.

Other assumptions were also made for various aspects of the impact of upgrading transit. The assumptions used are outlined below.

Assumptions - The following assumptions were made in order to assess the probable impact that the transit improvements would have with respect to air quality.

Plan implementation -

1. That the implementation timetable presented in the transit plan (see Appendix J) would slip one full year.
2. That the improvements would be implemented as outlined in the plan and in the same relative time frame and sequence.

Ridership -

1. That average daily ridership throughout the entire area during 1973 was approximately 35,000.
2. That from 1973 to 1975 daily ridership throughout the region would increase 18 percent because of gasoline pricing increases; therefore, daily ridership during 1975 would be approximately 43,400.
3. That ridership would increase 5 percent during 1976 owing to improved route coordination brought about by the transit plan; therefore, 1976 daily ridership throughout the region would be 44,700.
4. That ridership from 1976 to 1977 would increase by 3 percent owing to new routes and equipment; 1977 ridership is estimated to be 46,000.
5. That beyond 1977, ridership on individual bus lines would increase by about 1 percent per year through 1980; therefore, 1980 daily ridership would be about 48,800.

6. That average trip length for newly attracted trips is 12 miles.
7. That, for analysis purposes only, 50 percent of new ridership would be former, single-occupant auto drivers.

Effectiveness Calculations - From the assumptions above, estimates were developed of changes in vehicle-miles of travel (VMT). This analysis indicated that the potential reduction in daily VMT by light-duty vehicles owing to the first phase of the transit improvement plan would be 7800 vehicle-miles. There would be, however, an increase in daily VMT from heavy-duty diesel vehicles of about 700 vehicle-miles. In terms of emissions, the reduction of 7800 vehicle-miles of light-duty vehicle travel would mean a decrease in carbon monoxide and hydrocarbon emissions by about 162 kilograms and 31 kilograms, respectively, per day; while the increased bus travel would add about 20 kilograms of carbon monoxide and about 3 kilograms of hydrocarbons daily, resulting in a net reduction of 159 kilograms of carbon monoxide and 28 kilograms of hydrocarbons, daily. This represents about a 0.1 percent reduction in vehicular emissions of hydrocarbons during the first year of implementation.

Social Impacts

The overall social impact of the proposed transit improvements is favorable. The social benefits, in addition to improved air quality, include increased mobility for transit-dependent individuals, reduction in repair and maintenance-related motor vehicle expenses, and energy conservation in the form of reduced gasoline consumption.

A major benefit associated with improved public transportation is an increase in mobility for transit-dependent individuals. These transit dependents are the young, old, and economically disadvantaged. This description of the transit-dependent population is documented by Tables IV-6, IV-7, and IV-8, which provide the results of a survey of transit users.[7] As shown in Table IV-6, 27.8 percent of transit riders are

20 years of age or younger, while 18.0 percent are 60 and over. The fact that many of the transit riders are economically disadvantaged is underscored by the fact that 62.0 percent of present transit riders have a monthly income of $500 or less. The fact that many present transit riders are indeed dependent upon transit is indicated by the fact that 42.3 percent of the riders do not have access to an automobile (Table IV-8). Through the suggested improvements, the mobility of these individuals will increase. For some, this will mean better job mobility; for others, a journey to a shopping area or to a health facility will become easier. Table IV-9 gives a breakdown of the employment status of transit riders and shows that 59.4 percent of all riders are students. Improved service for this group will reduce the need for schools in the area to build additional parking facilities.

Table IV-6. PERCENTAGE DISTRIBUTION OF BUS RIDERS BY AGE AND SEX, LOWER PIONEER VALLEY, 1972

Age group	Male	Female	Total
Under 15	1.3	2.0	3.3
16 - 20	7.5	17.0	24.5
21 - 44	8.3	21.0	29.3
45 - 60	4.6	20.3	24.9
60 and over	3.7	14.3	18.0
Totals	25.4	74.6	100.0

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

Table IV-7. MONTHLY INCOME OF TRANSIT RIDERS, LOWER PIONEER VALLEY, 1972

Monthly income level (dollars)	Number	Percent	Cumulative percent
0 to 250	4,153	24.4	24.4
250 to 500	6,404	37.6	62.0
500 to 833	4,067	23.9	85.9
833 and over	2,391	14.1	100.0
Subtotal	17,015	100.0	
Not reported	4,676		
Total	21,691		

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

Table IV-8. CAR OWNERSHIP OF TRANSIT RIDERS, LOWER PIONEER VALLEY, 1972

Number of cars in household	Number	Percent
0	8,966	42.3
1	7,829	36.9
2	3,557	16.8
3 or more	849	4.0
Subtotal	21,201	100.0
Not reported	490	
Total	21,691	

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

Table IV-9. TRANSIT TRIPS BY EMPLOYMENT STATUS OF RIDERS, LOWER PIONEER VALLEY, 1972

Employment status	Respondents only		All riders[a]	
	Number	Percent	Number	Percent
Employed	10,681	52.1	10,681	27.6
Unemployed	1,271	6.2	1,271	3.3
Student	4,809	23.4	22,947	59.4
Housewife	1,815	8.9	1,815	4.7
Retired	1,931	9.4	1,931	5.0
Subtotal	20.507	100.0	38,645	100.0
Not reported	1,184		1,184	
Total	21,691		39,829	

[a] Estimated, including school ticket trips on Springfield and Holyoke Street Railway lines.

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

In addition to improving the mobility for those individuals who already depend upon public transportation, it is also considered that new riders, particularly commuters, will be attracted to bus travel. As shown in Table IV-10, 83.3 percent of workers in the Springfield-Chicopee-Holyoke SMSA use the automobile as their work-commuting mode of transportation. For these individuals, the use of public transit will reduce their repair and maintenance-related automobile expenses. This amounts to approximately \$0.07 per mile.* In addition, gasoline expenditures will also decline. An individual commuting 2600 miles per year (10 miles per day, 260 days per year) will thus save \$182 annually in repair, maintenance, and miscellaneous expenses. Further, assuming that this individual's automobile presently consumes 15 miles per gallon of gasoline, he will save an additional $100 in gasoline expenses. If the transit fare is $0.35 each way, this individual would save a net of $100 by taking the bus rather than driving.

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*Total coast of operating an automobile depends highly upon vehicle type, age, etc. This figure is representative of the variable costs of owning a full-size car in Massachusetts, exclusive of fixed costs such as insurance and exclusive of fuel, calculated separately.

A third area of benefit is the energy conservation potential of public transit. Buses require less gasoline per passenger mile than does the automobile. A widespread increase in transit usage would, therefore, provide for reduced gasoline consumption.

Economic Impacts

There are essentially two economic considerations associated with the proposed transit improvements. The first consideration is the cost associated with the service revisions, bus fleet modernization, and improved passenger amenities. The second is the distribution of these costs among federal, state, and local government units.

Table IV-11 presents the projected capital expenditures associated with the transit improvement program. As shown, a total of $2.03 million will be needed over the 2-year period. Up to 80 percent of this total could be obtained through the Urban Mass Transportation Administration (UMTA). Thus the State and local share of the capital requirements will be $406,480. If the State aid for transit debt service (under Chapter 161) is available to transit districts, then 50 percent of the local debt service costs might be absorbed by State funds.

Table IV-10. MODE OF TRAVEL BY PLACE OF WORK, SPRINGFIELD-CHICOPEE-HOLYOKE SMSA - 1970

Place of work	Number of workers by mode of travel to work				
	Car driver	Car passenger	Public transport	Other	Total
Springfield CBD	3,784	996	1,124	418	6,322
(percentage)	(59.9)	(15.7)	(17.8)	(6.6)	(100.0)
Elsewhere in Central Cities[a]	70,299	14,295	6,311	11,282	102,187
(percentage)	(68.8)	(14.0)	(6.2)	(11.0)	(100.0)
Balance of SMSA	43,547	8,669	1,168	8,899	62,283
(percentage)	(69.9)	(13.9)	(1.9)	(14.3)	(100.0)
Outside SMSA	18,384	3,208	968	1,486	24,046
(percentage)	(76.5)	(13.3)	(4.0)	(6.2)	(100.0)
Work Place Not Reported	7,862	2,021	917	2,106	12,906
(percentage)	(60.9)	(15.7)	(7.1)	(16.3)	(100.0)
Total	143,876	29,189	10,488	24,191	207,744
(percentage)	(69.2)	(14.1)	(5.0)	(11.7)	(100.0)

[a] Springfield outside CBD, Chicopee, and Holyoke combined.

Source: U.S. Census of Population and Housing, 1970. Springfield CBD employment is substantially under-reported, and employment elsewhere in central cities is correspondingly over-estimated by these census data.

Table IV-11. PROJECTED CAPITAL EXPENDITURES ASSOCIATED WITH CAPITAL IMPROVEMENT PROGRAM IN THE LOWER PIONEER VALLEY TRANSIT DISTRICT[a]

Program item	Expenditures (thousands of dollars)		
	1975	1976	Total
New buses	--	1,950.0	1,950.0
Registering fareboxes	--	39.6	39.6
Bus stop signs	12.0	12.8	24.8
Bus shelters	--	18.0	18.0
Total	12.0	2,020.4	2,032.4

[a] It is assumed that the program Wilbur Smith and Associates proposed is being implemented with an approximate 1-year lag from their estimates. Thus, for example, Wilbur Smith's expenditure estimates for 1974 are now assumed to take place in 1975. The 1976 figures provided above are the Wilbur Smith estimates for 1975.

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

The operating costs of the carriers are provided in Table IV-12 and Table IV-13. As shown by these tables, an operating deficit of $2.22 million is projected for 1975 and $2.32 million for 1976. Therefore, for this 2-year period the State will bear a $2.27 million cost with locales bearing an additional $2.27 million. It should be emphasized that not all of these costs arise because of the Transportation Control Plan. These are included here, however, since the improved transit system is an integral part of or closely tied to this plan.

Legal-Administrative Issues

The transit district will have the overall responsibility for implementing the proposed changes. No significant legal or administrative issues appear to exist.

Table IV-12. PROJECTED TRANSIT REVENUES AND EXPENSES - 1975

Item	Springfield Street Railway	Holyoke Street Railway	Western Mass. Bus Lines	Longueil Transportation, Inc.	Peter Pan Bus Lines (supported lines only)	University of Massachusetts	Five Colleges, Inc.	Total
Operating revenues	$3,064,950	$1,080,500	$490,100	$1,359,000	$178,500	-	-	$6,173,050
Expenses	4,157,975	1,262,000	483,900	1,581,175	201,000	$490,000	$216,600	8,392,650
Net income (Deficit)	(1,093,025)	(181,500)	6,200	(222,175)	(22,500)	(490,000)	(216,600)	(2,219,600)
Burden of deficit								
State[a]	546,513	90,750	0	111,088	11,250	245,000	108,300	1,112,901
Local	546,513	90,750	0	111,087	11,250	245,000	108,300	1,112,900

[a] Fifty percent State operating assistance

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

Table IV-13. PROJECTED TRANSIT REVENUES AND EXPENSES - 1976

Item	Springfield Street Railway	Holyoke Street Railway	Western Mass. Bus Lines	Longueil Transportation, Inc.	Peter Pan Bus Lines (supported lines only)	University of Massachusetts	Five Colleges, Inc.	Total
Operating revenues	$3,206,350	$1,115,400	$509,100	$1,474,500	$196,300	-	-	$6,501,650
Expenses	4,371,725	1,297,000	515,700	1,690,306	212,000	$508,660	$227,500	8,822,891
Net income (Deficit)	(1,165,375)	(181,600)	(6,600)	(215,806)	(15,700)	(508,660)	(227,500)	(2,321,241)
Burden of deficit								
State[a]	582,688	90,800	3,300	107,903	7,850	254,330	113,750	1,160,621
Local	582,688	90,800	3,300	107,903	7,850	254,330	113,750	1,160,621

[a] Fifty percent State operating assistance

Source: Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts.

TRAFFIC FLOW IMPROVEMENTS

General

Concept - Analysis of air quality in downtown Springfield indicated that several specific locations now experience excessive concentrations of carbon monoxide. In order to determine the nature of the emissions source, vehicular traffic, a study of existing traffic characteristics was performed (see Appendix E). From the traffic study it was concluded that low speeds and interruptions to traffic flow along Main Street are caused primarily by pedestrian-automobile conflicts, marginal friction resulting from the occupancy of curb-lanes by busses and illegaly parked or standing vehicles, and friction resulting from conflicting vehicle movements (left-turns and cross traffic). Along East Columbus Avenue, there was no evidence of serious traffic congestion associated with friction or capacity constraints; several potentially serious safety problems were identified, however. Traffic flow on portions of State Street is often impeded by illegally parked vehicles and by conflicting turning movements, as well as a result of capacity constraints at various points along the street. It was also indicated by the study that, while Main Street and State Street were operating at or near capacity, other important streets in the area appeared to have abundant reserve capacity available.

Because the emission rate of carbon monoxide along a street is extremely sensitive to both speed and smoothness of flow as well as the volume of traffic, a logical approach to reducing pollutant concentrations was to seek methods for influencing the speed-volume characteristics of traffic on streets where carbon monoxide problems were identified. Given the imbalances in operating conditions throughout the street network, it was decided that a network approach to the problem would be the most effective. Also, it was decided that Main Street should become the focal point of consideration for developing any areawide traffic control measure for two reasons. First, the most severe carbon monoxide pollutant problems were shown to exist on Main Street; and second, person-exposure potential in the area was highest along Main Street.

Alternatives Evaluated - Several basic concepts, each involving circulation changes of various configurations, were considered. The first involved creating a vehicle-free zone along Main Street from State Street to Liberty Street. While this measure would have several very positive aspects regarding environmental quality, it was considered that the loss in capacity of north-south vehicular flow would pose serious consequences elsewhere.

A second alternative was to convert Main Street to one-way operation. It appeared that this would have good potential to decrease vehicular traffic on the street and consequently result in higher operating speeds as well. Further analysis indicated that other compatible measures could be implemented to enhance the benefits derived from conversion of Main Street to one-way operation.

A third concept involved maintaining two-way operation on Main Street but implementing other measures such as reducing vehicular conflicts. While this was considered to be the least disruptive measure, it also would be the least effective in improving air quality on Main Street.

From the above analysis it was decided that the second alternative (one-way traffic on Main Street) would provide the best solution to the air quality problems on Main Street. Therefore this concept was expanded to include a number of additional elements, which together form the recommended traffic flow improvement plan outlined below.

Traffic Flow Improvement Plan

General - The traffic flow improvement plan about to be described is composed of several somewhat interrelated elements. The objective of the plan is to effect a redistribution of traffic on the downtown street system by means of a revised one-way circulation pattern augmented by other measures such as limited street closings, turn prohibitions, parking restrictions, and others.

Proposed One-Way Circulation System - As was stated previously it was concluded that the most desirable operating mode for Main Street in the downtown area would be as a one-way street. Therefore, based on limitations of the surrounding street network, it is recommended that Main Street be converted to one-way operation in the northbound direction, from State Street to Liberty Street. In theory, converting the street to one-way operation will decrease the existing traffic volumes and, at the same time, increase the available capacity of the street, therefore allowing smoother flow and improved operating speed. As part of this, a contra-flow ("wrong way") bus lane should be added to Main Street, which would also supplement the associated transit service improvements.

In order to further reduce interference to flow on Main Street as well as to discourage random circulation (i.e., driving around the block in search of curb parking, etc.) it is recommended that a number of other streets also be converted to one-way operation or partially closed to general traffic. Specific recommendations are as follows:

- Gridiron Street - Close to general traffic from Main Street to parking lot entrance/exit at 33 Gridiron Street.
- Lyman Street - Close to through traffic from Main Street to Dwight Street (but consider use for access to Amtrak station).
- Hampden Street - Convert to one-way operation westbound from Main Street to parking lot entrance near East Columbus Avenue.

- Fort Street - Close to general traffic.
- Bridge Street - Close to general traffic between Main Street and Barnes Street
- Hillman Street - Close to general traffic between Main Street and Barnes Street.
- Pynchon Street - Close to general traffic from Main Street to City Hall Drive.
- Court Street - Convert to one-way operation westbound from Main Street to East Columbus Avenue.
- East Court Street - Convert to one-way operation eastbound between Main Street and Market Street.

Also, it is recommended that State Street between West Columbus Avenue and Main Street be converted to one-way operation in order to expedite traffic flow along the street as well as to reduce traffic density in the vicinity of East Columbus Avenue. It appears that one-way operation in either direction would improve the existing situation, however, operation in the eastbound direction may prove to be the most advantageous operating direction. For this analysis, it was assumed that eastbound operation would be implemented. With State Street operating one-way, access to I-91 would be provided by Union Street, which should also be converted to one-way operation, but in a westbound direction from Main Street to West Columbus Avenue. Also, with this arrangement it would also be logical to convert Howard Street to one-way operation eastbound.

The possibility of closing the traffic loops between East Columbus Avenue and West Columbus Avenue at Memorial Bridge was considered. The presence of these loops appear to cause serious safety problems because of the limited weaving and merging distances available and the high volume of traffic involved in these maneuvers. Nevertheless, from discussions with engineering personnel from the District 2 Office of the Massachusetts Department of Public Works, it was concluded that a detailed study of the areas that would be affected by the closure (mainly East and West Columbus Avenues in the vicinity of State Street and

Hampden Street) should be undertaken prior to formalizing the recommendation. It is recommended, however, that the study actually be undertaken to determine the feasibility of closing the north loop or both the north and south loops. The entire one-way system proposed is shown in Figure IV-3.

It is emphasized that the proposed street closings are not intended to imply total closure of the streets involved (except for the traffic loops between East Columbus and West Columbus Avenues). The necessity for access by police, fire, and other emergency and service vehicles is recogonized, therefore it is not the intent to exclude vehicles of this nature. Also, these areas appear to be strategically located to serve as loading zones, therefore commercial pickup and delivery activity should be allowed within these street sections.

Coordinated Parking Program[8] - It is recognized that an essential commodity in the downtown economy is parking. Nevertheless, it is also recognized that access to the area is equally important. In previous times street systems in downtown areas were able to accomplish both functions - that is, provide access as well as storage for vehicles. But, in today's society where automobile traffic has increased by orders of magnitude, street systems often cannot serve both functions effectively. Given that the primary purpose of any street or highway is to provide access (move traffic), it should be clear which option (limit access, or limit parking) should be exercised when it is found that a particular street cannot provide both functions effectively.

The above discussion provides the basis for recommending that curb-parking be eliminated from streets in downtown Springfield as summarized in Table IV-14. It is considered that sufficient off-street parking is available in the vicinity of the sites where curb-parking removal is proposed so that serious inconveniences will not be experienced by patrons of local businesses.

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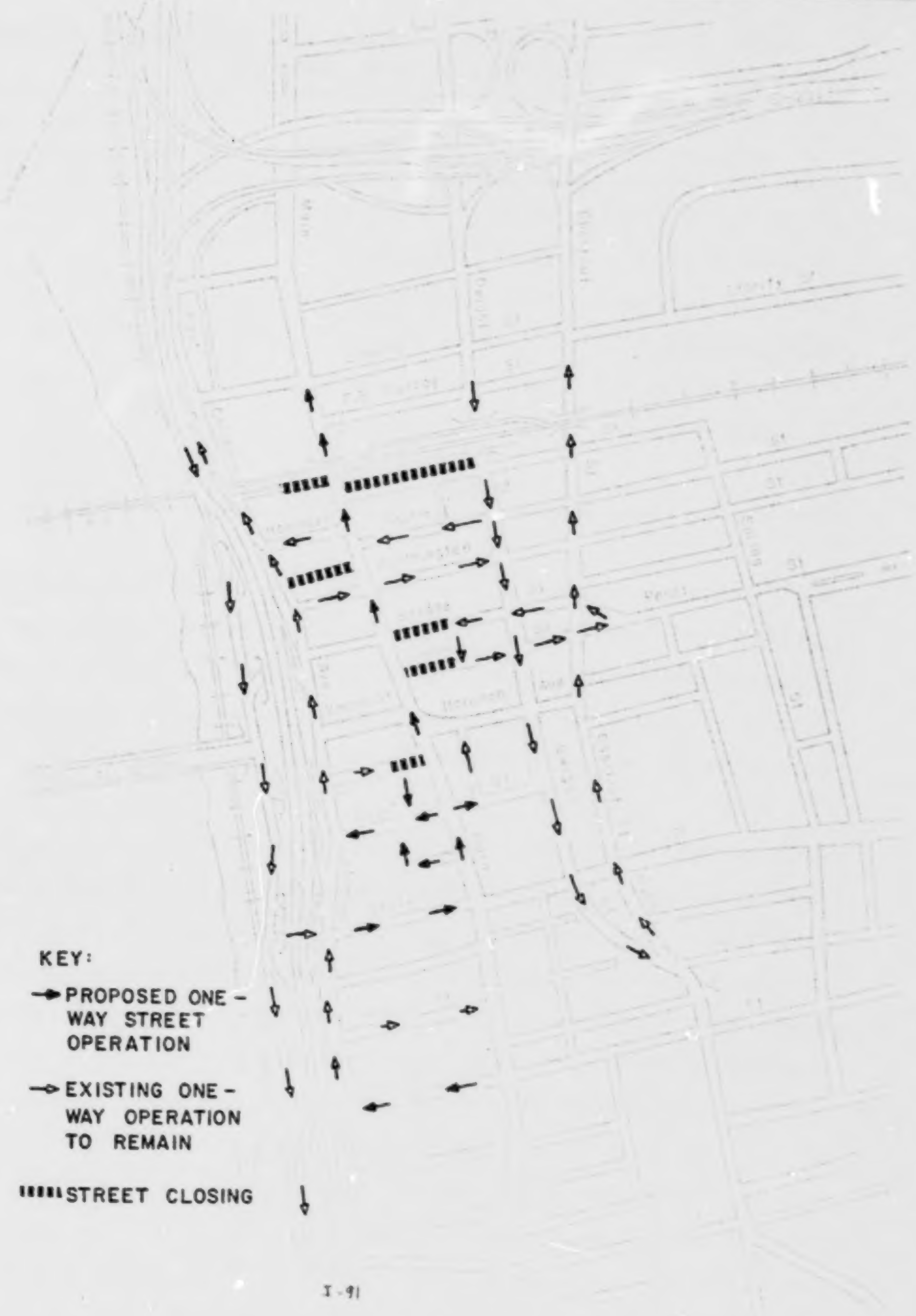
KEY:
PROPOSED ONE-WAY STREET OPERATION
EXISTING ONE-WAY OPERATION TO REMAIN
STREET CLOSING
I-91

CENTRAL BUSINESS DISTRICT - SPRINGFIELD, MASSACHUSETTS

Figure IV-3. Proposed traffic circulation system, downtown Springfield, Massachusetts

Table IV-14. RECOMMENDED REMOVAL OF CURB-PARKING IN DOWNTOWN SPRINGFIELD, MASSACHUSETTS

Street	Location	No. metered spaces eliminated (estimated)
Worthington Street	East Columbus to Dwight	25
Hillman Street	Main to Dwight	16
Harrison Avenue	Main to Dwight	5
Main Street	State to Union	23
Taylor Street	Main to Powers	20
Chestnut Street	State to Lyman	25
	. Total	114

Regulations establishing the "no parking zones" should be written to include prohibition of standing or live parking at the curb for any purpose, including pick-up or delivery (of passengers as well as goods). Exceptions cannot be granted because any parking for whatever reason would severely reduce the capacity of the street.

With a reduced supply of curb parking available, there will be increased competition for the remaining space. Unless controls are instituted, the remaining curb parking may tend to be occupied by long-term parkers, especially those who arrive early in the day. It would be preferable for such curb parking to be kept available for short-term parking. Adequate short-term parking is an aid to retail activity. Furthermore, plentiful short-term parking reduces idling and circulation of vehicles hunting for spaces. Persons parking for longer periods are more apt to be willing to walk an additional distance from a parking lot than are those whose errands are brief. Hence the concept should be to encourage persons wanting to park for any substantial time to use off-street parking.

Where curb parking remains within the area bounded by, and including, Bliss Street, West Columbus Avenue, Hampden Street, Worthington Street, Chestnut Street, and State Street, a time limit of one-half hour in duration should be established. Curb-parking in the remainder of the downtown area (bounded by the Connecticut River, the railroad viaduct, Chestnut Street, and State Street) should be limited to 1-hour in duration. Regulations should specify that these durations are in fact time limits and that "meter feeding" is a violation.

In order to make curb-parking restrictions and regulations work, rigorous enforcement measures must be implemented. This should include assigning additional personnel on the street as well as restructuring the existing fine system. It is recommended that the practice of multiple ticketing (whereby an illegally parked vehicle could receive more than one ticket per day) be instituted as well as the establishment of a towing program to remove illegally parked vehicles from important arterial streets. In addition, for a program of this nature to be effective, the public must understand its intent and must also preceive it as a reasonable and fairly-enforced program. The city must take the lead in setting the example by insuring that its own vehicle fleet abides by the regulations. Also, selective enforcement must not be permitted, although it is recognized that this is easier to accomplish in theory than in practice.

It is further recommended that the city develop a parking lot beneath the I-291 viaduct at Main Street and Boylston Street on an experimental basis to provide low cost or free all-day parking. A low-cost shuttle bus service would be required from this proposed parking lot to various points within the downtown area. This service should also be provided for outlying facilities such as the parking lots on Union and Bliss Streets, and others as deemed appropriate.

The last element of the coordinated parking program involves regulating wholesale/retail delivery activity within the downtown. Currently deliveries during peak traffic periods result in delays and congestion owing to blockage of travel lanes by delivery vehicles. It is proposed that the delivery of goods to the area be prohibited where and when it is adding to congestion, such as in the afternoon peak (3:30 to 5:30, say).

Spot Improvements - Various traffic engineering improvements at several locations will be required upon implementation of the proposed traffic circulation system. These are outlined below.

Liberty Street at East Columbus and West Columbus Avenues - It is expected that the major through-movement southbound from Main Street will occur over Liberty Street and West Columbus Avenue; therefore minor geometric modifications are required at the subject intersection. Primarily, this includes providing for the left-turn movement from Liberty Street to West Columbus Avenue southbound. Also, it is expected that signalization will be required at this intersection.

West Columbus Avenue from Liberty Street to Hampden Street - West Columbus Avenue operates one-way southbound through Springfield. North and immediately south of Liberty Street it is a two-lane facility. A short distance south of Liberty Street, however, West Columbus Avenue is delineated for one lane operation, owing to limited lateral clearance under the Boston and Maine Railroad bridge; south of the bridge the street again provides two lanes. In the vicinity of Hampden Street a turning loop provides access to West Columbus Avenue from East Columbus Avenue. Currently, traffic entering West Columbus Avenue from this loop must stop and wait for a sufficient gap in the traffic stream to occur before entering the street. Observing the oncoming West Columbus Avenue traffic flow from the loop is difficult owing to the sharp angle at which the streets intersect.

The ability for this loop to effectively provide a link between East Columbus Avenue and West Columbus Avenue is a key factor in the determination of whether the north loop of the Memorial Bridge rotary (see Proposed One-way Circulation System, above) could be closed to traffic.

In order to provide more efficient as well as safer functioning of this loop, it is recommended that West Columbus Avenue from Liberty Street, south to the loop, be delineated entirely for one lane operation with traffic channeled to the right side of the roadway as far as possible. This would permit free flow from the loop onto West Columbus Avenue, which would remain a two-lane facility south of the loop.

Taylor Street and Hampden Street at Main Street - Hampden Street and Taylor Street function as an important westbound arterial through the northern portion of the business district. These streets are offset by about 75 feet at Main Street, resulting in inefficient traffic flow. The Springfield Planning Department has recogonized this problem and has studied and confirmed the need for aligning Hampden and Taylor Streets. It is recommended here that this realignment project be advanced, but not in the context of a high priority item within the overall transportation control plan.

East Columbus Avenue at Vernon Street - It is expected that traffic volumes on Vernon Street will increase substantially as a result of the recommended circulation system. The increase in volumes expected may warrant signalization of the intersection.

East Columbus Avenue, West Columbus Avenue at State Street - If the south loop of the Memorial Bridge rotary were closed to traffic as recommended in earlier text, this area would require modification to insure free flow of traffic from West Columbus Avenue to East Columbus Avenue and to I-91 northbound. It is proposed that this be accomplished by not permitting traffic on East Columbus Avenue to merge to the I-91 northbound on-ramp just north of State Street. Rather, traffic would use the on-ramp north of Vernon Street. Channelization would be required to accomplish this.

Traffic Signal System - With the recommended changes to the circulation system, adjustments to the timing and phasing of the traffic signal system will be required. The existing system utilizes extensive interconnection and has the capability of being progressively timed and therefore it is recognized that making appropriate adjustments, particularly since extensive changes to the circulation system are contemplated, will be a sophisticated process requiring a high degree of traffic engineering expertise. This task, however, is essential to the overall plan and is considered to be of top priority.

Signing and Pavement Markings - The proposed circulation system and supportive measures outlined above will require extensive changes and improvements in traffic signing and pavement markings. These should be accomplished in accordance with specifications of the Manual on Uniform Traffic Control Devices.[9]

Evaluation of the Effectiveness of the Traffic Flow Improvement Plan

The traffic flow improvement plan outlined above is directed toward improving traffic operating conditions specifically in downtown Springfield. Because the strategy will have an influence on such a small area, it is not expected to affect hydrocarbon emissions significantly, so the assessment of the plan's effectiveness will be in terms of its impact on carbon monoxide only.

The method for assessing the plan involved determining its impact on traffic volumes for each link (as described in Section III of the report) in the downtown. This was accomplished through a traffic assignment technique that involved predicting travel paths through the downtown under different circulation patterns. The traffic assignment technique was based on actual trip data derived from the downtown traffic survey mentioned earlier. Essentially, the survey provided data on three types of trips: external to internal, internal to external, and external to external, where internal was defined as any point within the downtown study area (as defined previously), and external being any point outside the downtown. The principal element of data used was origin-destination information. For the external to internal and external to external trips, origin was defined as the point of entry to the downtown, and destination was defined as the link on which the vehicle was eventually parked (external to internal) or the point of departure from the downtown area (external to external). For internal to external trips, origin was defined as the link within the downtown area on which the vehicle was parked while destination was the point of departure from the downtown area. With the origins and destinations known, probable travel paths between all combinations of origins and destinations were determined through a manual process. Because the area in question is relatively small and utilizes many one-way streets, the choice of travel paths between any given origin and destination was quite limited; therefore, it is considered that the assignment process was reasonably accurate.

Once changes in link volumes were established, the new link volumes were compared with existing volumes and this, along with estimates of downstream characteristics that might affect flow, became the basis for judging whether the link speed would change so significantly that a new speed code (see Section III) should be assigned.

This process was repeated for three configurations of one-way streets and supportive measures, and the volumes and speeds determined for each were entered into the APRAC computer model to derive estimates of resulting carbon monoxide concentrations at the twenty locations used to assess existing air quality in downtown Springfield (see Section III for discussions of APRAC and the twenty locations, mentioned). Table IV-15 summarizes the change in carbon monoxide levels expected by

Table IV-15. COMPARISON OF PROJECTED 1976 CONCENTRATIONS OF CARBON MONOXIDE AT 20 LOCATIONS UNDER THE EXISTING CIRCULATION SYSTEM AND THE PROPOSED TRAFFIC CIRCULATION SYSTEM FOR SPRINGFIELD, MASSACHUSETTS

		Carbon monoxide concentrations calculated by APRAC			
		1976 concentrations with the existing circulating system[a,b]		1976 concentrations with the recommended circulation system[a,b]	
	Location	Highest concentration[c] (ppm)	Second highest concentration[c] (ppm)	Highest concentration (ppm)	Second highest concentration (ppm)
1.	State at Chestnut	5.37	5.34	5.30	5.26
2.	State at Dwight	10.69	10.60	8.60	8.55
3.	State at Main	10.04	9.98	3.35	3.34
4.	W. Columbus at I-91 Southbound off-ramp	7.85	7.80	10.18	10.11
	Off-ramp				
5.	W. Columbus at Memorial Bridge	7.64	7.59	9.99	9.92
6.	W. Columbus at State	5.55	5.51	10.47	10.40
7.	W. Columbus at Union	1.90	1.88	1.90	1.89
8.	E. Columbus at Union	3.81	3.78	3.02	3.01
9.	E. Columbus at State	6.82	6.78	10.90	10.85
10.	E. Columbus at I-91 Northbound On-ramp	6.41	6.39	10.59	10.53
11.	E. Columbus at Vernon	8.65	8.61	9.63	9.58
12.	E. Columbus at Worthington	4.67	4.64	9.66	9.62
13.	E. Columbus at Liberty	1.55	1.54	3.68	3.66
14.	Main at Hampden	4.46	4.45	3.23	3.22
15.	Main at Hillman	14.48	13.40	3.81	3.80
16.	Main at Vernon	13.35	13.26	2.32	2.30
17.	Main at Union	7.69	7.67	6.60	6.57
18.	Dwight at Worthington	7.09	7.07	2.11	2.11
19.	Dwight at Harrison	4.79	4.76	5.20	5.16
20.	Chestnut at Bridge	3.65	3.64	4.26	4.24

[a] As of 1 August 1976.

[b] Reflects impact of FMVECP

[c] See Section III for discussion on derivation of the data presented.

comparing projected 8-hour average concentrations (using "worst day" meteorology as defined in Section III) for 1976 with the existing and proposed traffic circulation systems.

This Table shows that the proposed circulation system's impact is mainly to reduce the maximum concentration in the area from 14.48 ppm (Main Street at Hillman Street) to 10.90 ppm (East Columbus Avenue at State Street). However, the standard of 9.0 ppm is still shown to be exceeded, therefore it can be concluded that additional control measures must be considered. Other measures proposed in the TCP will in fact have an impact on the carbon monoxide concentrations in downtown Springfield. The combined affects of control measures, however, will be discussed in Section V.

Social Impacts

For the purpose of this analysis, the recommended traffic flow improvements are discussed in three parts: one-way circulation system, parking controls, and spot improvements.

One-way Circulation System - The first item, a one-way circulation system, is not likely to create substantial social impacts of either an adverse or positive nature. There is likely to be some initial inconvenience for automobile users, in the form of route changes as well as increases in travel time. It is anticipated, however, that no significant long term social impacts will arise from the one-way circulation system. In this respect it is well to remember that one-way street patterns have been routinely used in downtown sections of American cities of all sizes, for decades.

Coordinated Parking Program - The coordinated parking program is likely to create the greatest social impacts of any of the three components of the traffic flow improvements. The removal of curb parking spaces will force many shoppers and commuters to utilize parking lots or garages. For those automobile users who are forced into lots or garages, the increased cost will be the differential between the off-street rates and the 10 cent per hour meter rate. Off-street rates range from $0.25 to $0.60 for the first hour of parking with each additional hour costing from $0.15 to $0.40. Daily rates range from $0.90 to $2.00 and monthly rates generally from $12.00 to $25.00. Table IV-16 provides the additional costs imposed on a variety of parkers.

Table IV-16. ON-STREET VERSUS OFF-STREET PARKING RATES

Hours parked	Metered	Off-street	Differential
1 hour or less	$0.10	$0.25-$0.60	$0.15-$0.50
4 hours	$0.40	$0.70-$1.80	$0.30-$1.30
8 hours	$0.80	$0.90-$2.00	$0.10-$1.20

It should be noted that, based upon the most recent parking survey, adequate capacity now exists to take care of the increased demand induced by the elimination of curb parking. In most cases, lot spaces exist near where the metered spaces are to be eliminated. Then little, if any, additional inconvenience in the form of increased distance to the traveler's objective appears likely.

The increased enforcement of the curb parking restriction and the proposed regulation limiting on-street parking to 1 hour is likely to meet with unfavorable public opinion. Larger fines, multiple ticketing, and a tow program may be unpopular since they tend to increase the cost to violators. Unless care is taken to ensure uniformity in issuing violation notices, a great deal of public resistance may arise.

The utilization of space under I-291 as a parking facility, and time restrictions on deliveries are not likely to create any social impacts of a significant nature, beyond the obvious reduction in congestion and improvement in air quality.

Spot Improvements - No discernable social impacts are expected to arise from this feature of the traffic improvements program.

Economic Impacts

The economic impacts associated with the proposed traffic improvement program can be categorized according to the sector affected. For purpose of analysis these sectors are (1) government and (2) the business community in general.

The economic impacts affecting the city government are primarily the capital and manpower costs that arise from the implementation of the measures. The most obvious costs are the pavement markings, signs, signalization, and construction required for the proposed changes.

Table IV-17 presents estimates of these costs based upon the costs of similar projects. As shown, an estimated total of $147,000 will be needed, including the labor associated with the improvements.

Table IV-17. CAPITAL COST ESTIMATES OF TRAFFIC FLOW IMPROVEMENTS[a]

ITEM	COST
Pavement markings	$1,500
Signs (100 installations at $100/installation)	10,000
Signalization	
Liberty at East Columbus/West Columbus	40,000
East Columbus at Vernon	40,000
Adjust signal phasing/timing	10,000
Construction (other than signalization)	
Liberty at East Columbus/West Columbus	10,000
Parking lot under I-291	1,000
Channelization along West Columbus-Liberty to Hampden	5,000
Channelization - East Columbus at State and I-91 on ramp	2,000
Removal of Parking Meters (114 at $25 each)	3,000
Subtotal	122,500
Contingency (20 percent)	24,500
Total	$147,000

[a] Source: GCA/Technology Division

In addition to the aforementioned capital costs, the city will incur two additional impacts. The first of these is a loss in meter revenues. The second is the manpower costs associated with increased enforcement.

A total of 114 metered spaces will be eliminated. This represents 26.2 percent of the total material facilities. The meter rate is 5 cents for 30 minutes with a 60-minute maximum. Assuming the meters are always utilized and that the time is paid for, a total of $91.20 per day will be lost. Assuming a 260-day year, the annual loss in meter revenues will be $23,712.

Assuming two additional traffic enforcement personnel are required by the proposed changes, manpower costs will be approximately $20,000 annually.

The business community will be affected in two major ways. First, the ban on deliveries during certain hours may force some businesses to stay open longer to accept deliveries as the trucks making the deliveries will be forced to reschedule their hours. Nevertheless, it is conceivable that the traffic flow improvements in general will provide for a more pleasant CBD environment. To the extent that this is true, the long run impact on business establishments should be favorable.

Legal-Administrative Issues

There appear to be no legal or administrative problems associated with the creation of one-way streets or providing signalization. City ordinances passed by the Springfield City Council must be approved by the Massachusetts Department of Public Works to bring about the required changes. This process is routine and presents no major problems.

The tow program involves a contractual arrangement between the City and a towing service. In addition, questions concerning the extent of liability to cars damaged while being towed must be studied, but have been addressed and resolved in numerous other U. S. cities.

In general, no significant legal or administrative problems appear to exist for the traffic improvement program beyond those normally associated with routine traffic engineering practices.

INSPECTION AND MAINTENANCE

Description

The purposes of an Inspection and Maintenance (I/M) Program are to ensure that motor vehicle emissions are kept to a minimum, and to ensure that degradation of emission controls in in-use vehicles is minimized over time. I/M is a source-oriented control strategy. As such, it allows for a reduction in emissions in the automobile itself, without requiring an associated reduction in vehicle-miles traveled (VMT). I/M is generally considered to be a mild control strategy in terms of social and economic impacts associated with it. Per capita costs resulting from implementation of an I/M Program are generally moderate to low. To the extent that required maintenance tends to increase the variable cost component of owning an automobile, Inspection and Maintenance Programs can be mildly socially regressive. The strategy results in no change in lifestyle, however, and it retains the characteristics of personal mobility associated with automobile usage.

Inspection and Maintenance Programs consist of two phases:

1. Inspection Phase - during which vehicles are inspected to determine if emission levels of carbon monoxide and hydrocarbons conform to predetermined emission standards; those vehicles requiring maintenance to bring them into conformance with emission standards are identified; and,

2. Maintenance Phase - during which vehicle malfunctions causing excessive emissions are corrected. Vehicles failing the first inspection are then reinspected.

Ultimately, an Inspection and Maintenance Program can accomplish a reduction in vehicular emissions only to the extent that it causes more or better vehicle maintenance to be performed than would have occurred voluntarily. In terms of actual motor vehicle emissions reduction, the frequency of inspection and the related rate and extent of emission control deterioration following vehicle maintenance and inspection will affect the actual air quality gains achieved through an Inspection and Maintenance Program.

Major I/M Program Configurations - There are different types of Inspection and Maintenance Programs. Major factors accounting for differences in these programs are: (1) scope and frequency of inspection; (2) method of emission testing; and (3) public versus private operation of inspection. Variations in these factors tend to cause substantial differences in the relative costs and degrees of effectiveness of Inspection and Maintenance Programs. Major issues associated with each are identified below.

Scope and frequency of inspection - "Inspection" may connote inspection for emission characteristics only, or it may involve a combination of safety inspection with vehicle emission characteristics. This latter approach is currently under discussion for Massachusetts. In addition, there are three alternative approaches to Inspection and Maintenance for emissions:

- Emission inspection - involving the sampling of exhaust gases for emission levels;
- Engine parameter inspection - involving an examination of selected engine components to determine if the vehicle is functioning according to manufacturers' specifications; and
- Mandatory maintenance - in which the inspection phase is avoided entirely. Instead, vehicles are periodically required to undergo specified maintenance procedures designed to bring emissions to acceptable levels for particular makes, models, and years of manufacture.

A comparative study of these three approaches was made for the Environmental Protection Agency on pre-1972 vehicles. The results of this study, as reported in the 1974 EPA document, "Inspection and Maintenance: A Guide for Implementation,"[10] are contained in Table IV-18.

Table IV-18. INITIAL REDUCTIONS IN POLLUTANTS WITH MAJOR INSPECTION STRATEGIES (PRE-1972 VEHICLES)[a]

I/M strategy	Percentage of vehicles serviced	Initial reduction in mean exhaust emissions (%)					
		From serviced vehicles			From total fleet		
		HC	CO	NO	HC	CO	NO
Exhaust emission inspections	50	25	19.0	0	13	9.5	0
Engine parameter inspection	95	11	6.5	0	10	6.0	0
Mandatory maintenance	100	15	11.0	0	15	11.0	0

[a] Source: Reference 10

In terms of emissions reductions within the population of vehicles serviced, exhaust emissions inspection achieves a significantly greater initial reduction in emissions than do engine parameter inspection or mandatory maintenance. In terms of emissions reduction within the total vehicle population (serviced and unserviced), which is a better indicator of the reduction in emissions that could be achieved through an I/M Program, all three approaches achieve comparable results. When cost-effectiveness is considered, however, the three approaches differ significantly. For the same amount of reduction, assuming a per capita cost of $2.50 for emissions inspection, $10 for engine parameter inspection, and $30 for mandatory maintenance, both the out-of-pocket cost and the time cost to the automobile-owning public is considerable for the latter two approaches. With exhaust emission inspection, it is apparent that the same amount of total fleet emission reduction can be achieved by servicing only half as many vehicles as would require servicing under the other two approaches. Given the greater cost-effectiveness of an emissions inspection program configuration, this approach would be recommended for consideration in Massachusetts. An annual emissions inspection could be one of the two major components of a combined Safety and Emissions Inspection Program conducted either statewide, or within specified air pollution control districts designated by the state. Emissions inspection could be performed on either an annual or a semiannual basis.

Method of emissions testing - The choice of an emissions testing mode determines how closely the emissions measured by an inspection procedure will correspond to the emissions to the atmosphere from vehicles in normal use. The choice of mode will also affect the amount of diagnostic information the emissions test will provide for vehicles failing the inspection. Two general categories of emission testing modes are currently in use:

- Idle Mode - during which pollutant levels within the exhaust gas are measured during normal idle operation of the vehicle, and
- Loaded Mode - (also called dynamic or key mode) in which exhaust emissions are measured while the engine is loaded by a chassis dynamometer to simulate actual driving conditions.

In general, loaded mode testing is considered by EPA to be a better indicator of vehicle emissions during actual driving conditions. A potential advantage lies in its ability to identify vehicles having malfunctions observable only when the engine is under load. Loaded mode test procedures have a higher correlation with the Federal Certification Test Procedure used by EPA for new vehicles. In addition, loaded mode testing can produce approximately 4 percent greater reduction in hydrocarbon emissions than is true of idle mode testing. In terms of time required for testing, a loaded mode test takes about 3 minutes to perform as opposed to about 2 minutes for idle mode test.

Although loaded mode testing is a better indicator of emissions and it has the ability to generate better diagnostic information about the type of maintenance required in failed vehicles, there are factors that could mitigate against its use. The costs of selected types of testing equipment for the two modes are listed in Table IV-19. As Table IV-19 indicates, the cost of the most elementary type of idle mode emission inspection equipment is $1,800 per inspection lane; the cost of loaded mode inspection equipment ranges from $14,000 per lane for the basic type Clayton Key mode, to $60,000 per lane for highly sophisticated equipment utilizing automatic data treatment. The idle mode test is also a simpler test to perform. It requires the simplest instrument system and needs no dynamometer. Pass or fail can be indicated by lights on the instrument set to activate at established fail points and the inspector need only indicate which pollutants are above the standard. Also, idle mode inspection lanes have a greater annual capacity (32,000 vehicles/lane, as opposed to 25,000 vehicles/lane for key mode). Thus the cost per vehicle tested is lower for idle mode inspection.

Table IV-19. COSTS OF EQUIPMENT FOR EMISSION INSPECTION

Idle emission inspection	
Infrared hydrocarbon/carbon monoxide instrument (simple meter readout with pass/fail lights)	$ 1,800
Loaded vehicle emission inspection	
Loaded constant speed modes (key modes)	
Simple instrumentation for HC/CO	3,000
Dynamometer with power absorption	11,000
	14,000
Constant speed acceleration and deceleration modes	
Simple instrumentation	3,000
Dynamometer with power absorption and inertia	18,000
	21,000
Fully automated system	60,000
Accurate instrumentation	
Automatic data treatment	
CVS system	
Dynamometer with power absorption and inertia weights	

Source: Inspection and Maintenance - A Guide for Implementation. U.S. Environmental Protection Agency, Strategies and Air Standards Division. February 1974. p. 25

Given the high acquisition cost of loaded mode equipment and the higher level of skill required to perform the inspection, the most cost-effective application of loaded mode testing is in a state-operated inspection program, in which the inspection procedure is performed regularly on a high throughput basis by skilled personnel. Loaded mode testing is also the mode of choice if the maximum amount of hydrocarbon pollutant reduction is required, and if better diagnostic information (and thereby, lower maintenance costs, with less unnecessary maintenance) is given priority over capital investment in inspection equipment.

Public versus private operation of inspection - Main operational configurations for I/M are: (a) state-owned or franchised inspection lanes, and (b) private garages licensed by the state to perform emissions inspection in addition to their normal operations. A state-conducted random pullover program has also been considered by states currently setting up I/M Programs. Principal factors influencing selection of a method of operation are:

- The overriding need for consistency in the application of pass/fail criteria between inspection stations.
- The need for high diagnostic capability within inspection facilities, and related to it, the ability to protect the public from the cost of unnecessary repairs and from price-gouging.
- The minimization of inconvenience to the vehicle-owning public, in terms of station location and total time required for the inspection.
- The ability of garage mechanics and repair facilities to accommodate the demand for inspection and repairs generated by an I/M Program.
- The possible pre-existence of a licensed private garage program for safety inspection, as is true in Massachusetts; and
- The political acceptability of alternative operational configurations.

Evaluations of the relative effectiveness of Random Pullover, Private-licensed I/M and State I/M generally conclude the greatest emissions reductions to be achievable through a state operated or franchised I/M Program. Random Pullover is found to be almost completely ineffective, given the small percentage of the total vehicle population covered each year. In addition, Random Pullover requires that the ability of the state to meet ambient air quality standards be based on the dual probability that high-emitting vehicles will be selected at random, and that the psychological reaction of the vehicle-owning population will be to undertake emissions-related maintenance even though any individual vehicle may be stopped only once every 10 years. Random Pullover is also more difficult to follow up and enforce.

As Massachusetts currently has a statewide safety inspection program which operates through private licensed stations, the state is considering a private licensed station approach to emissions inspection, as well. Advantages associated with this approach include the following:

- The private licensed station configuration is generally considered to be more acceptable politically, in particular as compared to state operated inspection. In addition, an administrative and bureaucratic structure already exists for inspection by private stations.
- The private licensed station approach reduces the financial burden on the state. No major capital expenditure is required for constructing state inspection facilities either within specified air pollution control districts or throughout the state. At most, one or two centrally located state garage facilities may be necessary to serve as training centers or as complaint and referral centers for vehicle malfunction diagnosis and for vehicle retesting.
- The private station configuration permits vehicle owners to utilize inspection facilities in private stations that are already familiar with the operating characteristics of their vehicles. Such stations may also be more conveniently located and more numerous, particularly as compared to a state station program in which there may only be one station per county. (It should be noted that vehicle owners could continue to use their regular repair facility

for any required maintenance, regardless of whether the inspection were conducted in a private or state facility, however.)

The disadvantages of a private licensed station configuration are based upon the relative ability of the inspection program to effectively reduce emissions, and thereby fulfill the objective for which it is intended. Major disadvantages include the following:

- Under a system of private garages licensed by the state to perform Safety and Emissions Inspection, it is more difficult to ensure uniformity of criteria for passing or failing emissions inspection. Some stations may be more lax in enforcing emission standards than are others, and such nonuniformity could subtract from the overall effectiveness of the program.
- The tendency of garage mechanics to tune "by ear," without regard to emission characteristics, may lead to unnecessary and/or excessive maintenance being performed in vehicles failing to meet emission standards. This is particularly true if private garages are both conducting the inspections and performing the maintenance procedures. To an extent, this factor may be modified by state policing and spot checking of private garage inspection facilities.
- In view of the better diagnostic information provided by loaded mode testing, greater consumer protection may be afforded by use of loaded mode test. However, a private licensed garage system is not cost-effective for loaded mode testing, in that it would require individual station owners to pay some $14,000 for emission testing equipment which would receive only periodic, relatively low volume use.

The key characteristics of a state-run inspection program, the other major I/M operational configuration, are as follows:

In a state operated or franchised program, inspection facilities receive the regular, high volume use required to make loaded testing equipment cost-effective. Specially trained personnel perform testing on a continuous basis, and would be capable of making diagnostic recommendations - thus helping to reduce the incidence of excessive repair costs.

The physical separation of the agencies performing the inspection procedure from those performing maintenance procedures could also serve to reduce the incidence of unnecessary maintenance. Disadvantages are that a state operated system would require a significant expenditure of state funds for the capital construction of inspection facilities. In addition, it would require a major revamping of the existing administrative structure for safety inspection. In order to avoid the financial burden associated with state-run I/M, some states are considering franchising the program to a private contractor.

As can be seen from the above, there are important factors that merit consideration before the Commonwealth of Massachusetts makes a final decision on a particular type of program or test mode. For this reason, the major characteristics of each type of program have been reviewed, and capital and operating costs associated with two program configurations are presented. At the present time, the Commonwealth, in consultation with EPA, is studying a number of different I/M programs and options. Two configurations that are receiving considerable attention are (1) private licensed station program with idle testing performed on a semiannual or annual basis; and (2) state operated inspection program with loaded mode testing performed on an annual basis.

Under the Private Licensed Station configuration, the Registry of Motor Vehicles would license private repair facilities to conduct a comprehensive safety and emissions inspection. The current[*] thinking is for the existing safety inspection program to be totally revamped. Private stations would be licensed in proportion to the number of vehicles registered within a particular city or town, with one station per 2,500 registered vehicles. A full safety and emissions inspection, taking approximately 25 minutes, would be required. Emissions testing would be done with idle mode testing equipment. To be licensed, inspection facilities would have to comply with specified state requirements concerning equipment, procedures, and hours of operation, and stations would be strictly supervised by the state. A regulation is now being outlined whereby stations that were in violation of inspection procedure standards would face a statutory revocation period of varying lengths of time, depending on the severity of the violation. Current thinking is for inspections to be done on a staggered annual basis, although semiannual inspection would also be possible.

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[*] As of the spring of 1975

Under the State-run Inspection Program configuration, the Commonwealth would be responsible for constructing and staffing state garages for emissions inspection. Testing would be performed with loaded mode equipment and could be done on a staggered basis, annually or semiannually. At the present time, however, a semiannual inspection program appears to be prohibitively expensive, in that it would require that twice as many stations be constructed and staffed as would be required for an annual inspection program. A possible variation of the state-run program would be to franchise the program to a private contractor. Under this approach, capital and operating costs would be borne by a private contractor who would partially shift program costs onto the general public through a higher inspection fee.

In the following discussion, the effectiveness and impacts associated with the Private Licensed Station and State-run Inspection Programs are addressed. For purpose of analysis, a motor vehicle population of 260,000 vehicles has been assumed,* and an initial failure rate for emissions testing under both types of programs is assumed to be 40 percent. It should be noted that analysis is focused upon the costs, impacts, and effectiveness of implementing a program within the Springfield AQSA only, and not on a statewide basis. The assumption is that emissions inspection would be performed on all light-duty vehicles registered in the three counties within this district on an annual or semiannual basis, as applicable. Any maintenance required on vehicles failing the emissions test would be performed in private repair facilities, and failed vehicles would be retested after maintenance was performed.

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*Actual number of light-duty vehicles registered in Hampden, Hampshire, and Franklin counties in 1973 was 250,898.

Effectiveness of Inspection and Maintenance

Several forms of Inspection/Maintenance were reviewed in the preceding text. At the time the draft of this report was prepared, several alternatives were being considered for Massachusetts. Since then, however, the Transportation Control Plan for Boston was finalized; that plan[5] calls for the use of an idle mode inspection, and the frequency will probably be annual. The I/M regulation will apply to all light-duty automobiles (passenger cars and trucks).

Hydrocarbons — Table IV-20 presents the results of the analysis of the expected I/M program for Springfield. The analysis assumed an annual inspection, idle mode, 40 percent failure rate, and applicability to all light-duty vehicles (LDV) and light-duty trucks (LDT). Emission reductions were applied only to the exhaust component of vehicular hydrocarbon emissions (that is, evaporation is not affected). I/M is seen to reduce total vehicular hydrocarbon emissions by 4.8 percent

The data in Table IV-20 are based upon a fully-effective program by each tabulated date. This means that for the stated emission reductions to occur it would be necessary for all LDV and LDT vehicles to have been inspected. With an annual inspection, a full year of program operation is required for full effectiveness. Thus, for example, the program can be fully effective on 31 December 1976 only if inspections begin in January 1976. If inspections do begin in January 1976, about 60 percent of the vehicles would be inspected by 1 August 1976 (the compliance date for CO and the date used for oxidants analysis in the draft of this report); the

Table IV-20. ESTIMATED EFFECT OF INSPECTION/MAINTENANCE PROGRAM ON HYDROCARBON EMISSIONS IN SPRINGFIELD AQSA[a,b]

	Emissions (kg/day) on various dates			
	1 Aug. 76	31 Dec. 76	31 May 72	31 Dec. 77
LDV emissions without I/M	28,733	27,799	27,061	26,027
LDV emissions with I/M[c]	27,009	26,131	25,437	24,465
Reduction from I/M	1,724	1,668	1,624	1,562
LDT emissions without I/M	7,704	7,556	7,483	7,381
LDT emissions with I/M[d]	7,180	7,042	6,974	6,879
Reduction from I/M	524	514	509	502
Other vehicular emissions[e]	10,157	10,070	10,007	9,918
Total vehicular emissions				
Without I/M	46,594	45,425	44,551	43,326
With I/M	44,346	43,243	42,418	41,262
Reduction from I/M	2,248	2,182	2,133	2,064
Percentage of total vehicle emissions	4.8	4.8	4.8	4.7

[a] Table shows effect of annual, idle-mode inspection with 40 percent failure rate. Table assumes program is fully effective by each date. I/M reduces exhaust hydrocarbon emissions by 11 percent.

[b] Stated emissions include both exhaust and evaporative components, but I/M affects only the exhaust component.

[c] Exhaust emissions represent 54.1 percent of total LDV emissions, August 1976.

[d] Exhaust emissions represent 61.9 percent of total LDT emissions, August 1976.

[e] Other vehicle categories not subject to I/M are defined and explained in Section III.

emissions reductions under that case would be about 60 percent of those in Table IV-20. Emissions reductions for other combinations of inspection schedules and analysis dates can be estimated in a similar manner.

The Boston TCP[5] calls for inspections to begin in August 1976. Thus, full effectiveness of the Boston program will not occur until August 1977. It is reasonable to assume the Springfield area I/M program would be in operation no earlier than Boston's and probably later. The implications of this for the attainment of standards will be discussed in Section V.

Carbon Monoxide – The estimated changes in carbon monoxide concentrations that would be expected at the 20 locations studied in downtown Springfield are shown in Table IV-21, based upon the use of idle-mode annual inspection as discussed above. I/M would reduce CO emissions of light-duty vehicles by 9 percent. If I/M is delayed, effectiveness would be reduced, as discussed above.

Legal and Administrative Issues

Under the existing legal-administrative framework, the Massachusetts Registry of Motor Vehicles and the Massachusetts Department of Public Health are the primary agencies responsible for establishing an inspection program and for determining motor vehicle emission standards respectively.

Under Chapter 90, section 7A of the Massachusetts General Laws , the Massachusetts Registry of Motor Vehicles is directed to promulgate regulations requiring all motor vehicles to be inspected twice a year. Although the statute does not specify how the inspection program is to be carried out, the Registry has established a system of private garages which the Registry "qualifies" as "official inspection stations." Under Chapter 90, section 7A, each station is required to inspect "pollution control systems or devices," in addition to vehicle safety systems and devices. This Chapter also directs the Registry to promulgate rules and regulations "for the purpose of determining whether (motor vehicles) are in compliance with motor vehicle

Table IV-21. EFFECTS OF INSPECTION AND MAINTENANCE ON CARBON MONOXIDE CONCENTRATIONS AT 20 LOCATIONS IN DOWNTOWN SPRINGFIELD MASSACHUSETTS

Location	Projected 1 August 1976 worst case concentrations - ppm			
	No controls[a,b]	Idle mode inspection and maintenance[c]		Loaded mode inspection and maintenance[c]
		Annual	Semiannual	
State at Chestnut	5.37	4.89	4.62	4.78
State at Dwight	10.69	9.73	9.19	9.51
State at Main	10.04	9.14	8.63	8.93
W. Columbus at I-91 southbound off-ramp	7.85	7.14	6.75	6.99
W. Columbus at Memorial Bridge	7.64	6.95	6.57	6.80
W. Columbus at State	5.55	5.05	4.77	4.94
W. Columbus at Union	1.90	1.73	1.63	1.69
E. Columbus at Union	3.81	3.47	3.28	3.39
E. Columbus at State	6.82	6.21	5.86	6.07
E. Columbus at I-91 northbound on-ramp	6.41	5.83	5.51	5.70
E. Columbus at Vernon	8.65	7.87	7.44	7.70
E. Columbus at Worthington	4.67	4.25	4.02	4.16
E. Columbus at Liberty	1.55	1.41	1.33	1.38
Main at Hampden	4.46	4.06	3.83	3.97
Main at Hillman	14.48	13.18	12.45	12.89
Main at Vernon	13.35	13.15	11.48	11.88
Main at Union	7.69	7.00	6.61	6.84
Dwight at Worthington	7.09	6.45	6.09	6.31
Dwight at Harrison	4.79	4.36	4.11	4.26
Chestnut at Bridge	3.65	3.32	3.14	3.25

[a] No controls other than FMVECP.

[b] See Section III for a discussion on the development of the data presented.

[c] Assumes I&M program is fully effective by 1 August 1976

air pollution control regulations which are adopted (by the Department of Public Health) under the provisions of Massachusetts General Laws, Chapter 111, and which are consistent with applicable federal laws." At present, Registry rules and regulations do not provide for detailed air pollution control standards. According to registry officials, their regulations provide basically for visual emission checks.

The principal state agency responsible for air pollution problems generally is the Department of Public Health. Under M.G.L. Chapter 111, Section 142A et seg., the DPH is given general regulatory power over air pollution sources. All state agencies, commissions, authorities and political subdivisions of the Commonwealth are subject to DPH rules, regulations and orders relative to air pollution control. Under Chapter 111, Section 142B, DPH personnel are authorized to "stop and detain for inspection any motor vehicle for purposes of investigating either an actual or suspected source of air pollution or contamination or for ascertaining compliance" with air pollution rules, etc. Although this section also provides that the powers granted therein shall not "abrogate" the powers and duties of other state agencies including, presumably, the Registry and its vehicle pollution abatement responsibilities, the DPH is also currently authorized to enter the emission control and inspection field if it wishes to assert its jurisdiction and seek necessary appropriations.

It should be noted that considerable ambivalence exists under the present framework as to which agency, DPH or the Registry, should take the lead on defining enforceable standards and regulations relative to air pollution from motor vehicles. In particular, the regulations promulgated by the Department of Public Health pursuant to Chapter 111 and referred to in Chapter 90, section 7A quoted above, do not provide enforceable standards for air pollution emissions; instead, the DPH regulations specify that vehicles shall meet standards set by the Registry. Motor vehicle-related regulations that have been promulgated by DPH pertain to excessive emissions of visible air contaminants only.

Although no additional enabling legislation would be required, it should be noted that additional statutory authority may be required to actually fund, carry out, and enforce a program for emissions inspection. The large funding requirements, particularly of a state-operated program configuration, would require approval by the Legislature of a bond issue or appropriation sufficient to get the program under way. It may also be expected that the Legislature would require demonstration of adequate mechanisms for public protection and rate regulation before approving any particular program configuration.

Approximately 2 years would be required for implementation of an I/M program. According to the EPA document Inspection and Maintenance: A Guide for Implementation,[10] "the estimated time required for a State owned program is 26 months for an idle test and 29 months for a loaded mode test. For a State licensed idle test program the time required is about 26 months." These time estimates include the first year of inspections, but are exclusive of the time required to obtain legal authority and to make necessary funding arrangements. If there is public and political opposition to an Inspection/Maintenance Program, these factors can be critical determinants of the total time required for implementation. It is expected that the time required for implementation of a contractor-financed and operated program configuration would be similar to the above estimates in that the time required for submission of bids and selection of a contractor would more than offset the time saved by selecting an experienced firm to set up the program and by the reduced opposition to the impact of the program on the State budget. (See also Section VI.)

Social Impacts

The motor vehicle-owning population in the 3-county Springfield AQSA would bear the cost of vehicle inspection (in the form of inspection fee, and personal inconvenience and time) and the cost of undertaking maintenance that may be required to bring vehicles into compliance with emissions and safety standards. In 1973, there were 250,898 light-duty (passenger) motor vehicles registered in Franklin, Hampden, and Hampshire Counties. By the time an inspection and maintenance program would be operational, a total vehicle population (TVP) of 260,000 vehicles has been estimated for the purpose of analysis.*

The cost of the inspection procedure would apply to all 260,000 vehicle owners. As will be discussed in the following section, an inspection fee of approximately $1.50 to $5.00 per vehicle may be necessary in order to cover the cost of the program to the State, and also in order to recover equipment and operating costs to the private licensed stations. Assuming a $5.00 fee, total public outlay would be $1,300,000 if inspection were done annually, and $2,600,000 if done semiannually.

A significant additional cost to the public resulting from implementation of an I/M program is the cost of the maintenance that is required on vehicles failed by the inspection test. This cost includes both the cost for diagnosing vehicle failure and the cost for labor and parts to perform the necessary repair. As discussed previously, a state-run (or contractor franchised) inspection procedure is generally thought to provide better diagnostic information - particularly if loaded mode test is performed. In addition, the incidence of unnecessary or excessive maintenance is considered to be lower under a state run or franchised program than under a private licensed station program. If the Commonwealth were going to establish a private licensed station program, a mechanism for adequate consumer protection would be required, particu larly for the maintenance phase of the program.

The cost for maintenance on failed vehicles is generally $25.00 to $30.00 for emission-related maintenance, as shown in Table IV-22.

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* At the time of this analysis, I/M was expected to apply to only LDV. If I/M is also applied to LDT, as expected, the number of vehicles affected and the aggregate costs would be roughly 12 percent higher than presented here.

Table IV-22. FLEET REPAIR COSTS FOR I/M

	California		Michigan	
	Idle mode	Key mode	Idle mode	Key mode
Actual cost per service vehicle	$27.33	$32.08	$23.29	$36.56
Corrected cost per serviced vehicle	27.38	26.57	28.29	28.36
Corrected total fleet average cost	10.90	10.20	9.30	9.40

Source: TRW. Socio-Economic Impacts of the Proposed State Transportation Control Plans: An Overview. Prepared for Environmental Protection Agency, November 1973. Page 68.

According to EPA personnel, ". . . maintenance costs for vehicles that fail the emissions tests are typically about $25.00." Data in the literature supports this estimate, although vehicles requiring repairs in excess of $100.00 were excluded from the analysis. The data in Table IV-22 would indicate an estimate closer to $30.00, particularly since the table estimate is in 1972 dollars. According to EPA, high maintenance costs for key mode are "not unexpected, since the diagnostic capabilities of the loaded mode test provide justification for more comprehensive, and generally more costly, repair actions." If safety defects are also corrected, an additional expenditure of $20.00 to $30.00 may be required.

Two key factors influencing the total cost expended for maintenance are 1) the frequency of inspection, and 2) the established failure rate. The inspection frequency will determine if vehicle owners are required to bring in their cars for inspection and then undertake possible mandatory maintenance on an annual or semi-annual basis. The failure rate will determine what percentage of the population is required to undertake maintenance, as well as the extent of maintenance that may be required.

As shown in Table IV-23 different failure rates will produce different levels of reduction in ambient levels of pollution. Assuming a $30.00 average cost for emissions-related maintenance, and applying the emissions reductions achievable under different failure rates, the total annual expenditure for maintenance associated with annual and semiannual inspection are shown in Table IV-23.

Table IV-23. EMISSIONS REDUCTIONS AND ASSOCIATED MAINTENANCE EXPENDITURES (IDLE MODE INSPECTION)

	Annual inspection			Semiannual inspection		
Failure rate (%)	CO	HC	Total annual maintenance expenditure	CO	HC	Total annual maintenance expenditure
10%	3	6	$ 780,000	5	9	$1,560,000
20%	6	8	1,560,000	9	12	3,120,000
30%	8	10	2,340,000	12	15	4,680,000
40%	9	11	3,120,00	14	16	6,240,000
50%	10	11	3,900,00	15	16	7,800,000

As can be seen from Table IV-23, a 40 percent failure rate would require a total annual maintenance expenditure of $3.12 million if inspection were annual and $6.24 million if semiannual.

In determining a failure rate also for the revised safety inspection phase of the program, there could be considerable overlap between the set of vehicles failing emission inspection and those failing safety inspection. Assuming that a 40 percent failure rate were used in both facets of the inspection, there could be as much as a 50 percent overlap between the emissions failure group and the safety failure group. This would mean that 60 percent of the state's motor vehicle owners could be required to spend between $30.00 to $40.00 for maintenance.

Using an "average" cost for maintenance disguises the fact that some vehicle owners - notably, owners of older or poorly maintained cars - may be required to pay significantly greater costs for maintenance. The poor currently own the oldest cars, drive the fewest miles, and maintain their vehicles least. Under an I/M program, they will have to undertake mandatory repairs of their vehicles in order to meet emission standards. To some extent, mandatory maintenance will duplicate maintenance that would eventually have been performed voluntarily. In other cases, however, mandatory emissions-related maintenance will be substituted for other types of maintenance (or nonmaintenance) related expenses.

Table IV-24 below indicates the weekly disposable income of a "typical" resident in 1973, according to the U.S. Bureau of Labor Statistics. These figures are based upon data for Hartford, Connecticut, in the absence of information specific to Springfield.

The weekly disposable income of a lower income family is $140.15; of an intermediate income family $206.77; and of an upper income family $275.65. From this amount, rent, food, clothing, and other expenses must be deducted. For the lower and intermediate income family, the remaining discretionary income is low, particularly in light of the 12 percent increase in the cost of living. Also, these estimates do not include consideration for the high rate of unemployment in the State. The annual transportation-related budget of auto-owning families, by income group, as estimated by the Bureau of Labor Statistics is:

1.	Lower income	$ 807
2.	Intermediate income	1,163
3.	Upper income	1,381

Table IV-24. DISPOSABLE WEEKLY INCOME

Group	Yearly income	Weekly income	Federal tax	State tax (Mass.)	Social Security	Disposable income
U.S. urban average						
Lower	$ 8,181	$157.33	$13.30	$ 3.66	$ 9.20	$131.17
Intermediate	12,626	242.81	28.50	8.16	14.20	191.95
Upper	18,201	350.02	54.10	13.66	20.48	261.78
Springfield						
Lower	8,909	171.33	16.50	4.66	10.02	140.15
Intermediate	13,721	263.87	32.50	9.16	15.44	206.77
Upper	19,127	367.83	56.50	14.16	21.52	275.65

Source: Bureau of Labor Statistics, U.S. Department of Labor - Urban Family Budget Data; federal and state (Massachusetts rates used in computation) taxes and social security applicable to BLS's urban family of four deducted.

Table IV-25. TYPICAL TRANSPORTATION-RELATED BUDGET FOR AUTOMOBILE-OWNING FAMILY BY INCOME

Category	Percentage importance	Low income budget	Intermediate income budget	High income budget
Original vehicle cost depreciated	32.4	$261.47	$ 376.81	$ 447.45
Maintenance, accessories, parts, and tires	19.1	154.14	222.13	263.77
Gas and oil (excluding taxes)	15.4	124.28	179.10	212.67
Garage, parking and tolls	13.2	106.52	153.52	182.29
Insurance	10.3	83.12	119.79	142.24
State and federal taxes	9.6	77.47	111.65	132.58
Total	100.0	$807.00	$1,163.00	$1,381.00

Note: Calculation technique - percentage importance x auto trans. factor from BLS 4 family budget study, July 1974.

Source: Liston, L. L. and C. L. Gauthier, Cost of Operating an Automobile. U.S. Department of Transportation, Federal Highway Administration. April 1974.

Assuming that the typical driver spends 13.6 cents per mile, and applying the percentage breakdown of auto-related expenses defined by the U.S. Department of Transportation, auto-owning families would have to limit expenditures as shown in Table IV-25 in order to keep within this budget.

For the purpose of analysis, it is assumed that the major method available to lower income groups to limit auto transportation expenses is to drive less, and thereby reduce expenses related to maintenance and parts, gas and oil, and parking and tolls; i.e., those factors that vary the most with distance driven. This assumption is supported by data from the Federal Highway Administration's Personal Transportation Survey, which found average annual miles per automobile to be related to annual household income.

A safety and emissions inspection and maintenance program would require that maintenance be undertaken regardless of distance driven, however. The effect would be to increase the operating cost of owning an automobile. This effect is potentially socially regressive, in that it would adversely affect the poor who are least able to absorb additional automobile operating costs.

The impact of an I/M program on owners of older vehicles may be lessened by the state application of different emission standards to different model year groups. Thus, while adhering to an overall failure rate of 40 percent, for example, three different emission inspection standards could be established for pre-1968 vehicles, 1968 to 1969 vehicles, and 1970 to present vehicles, respectively. An additional way to reduce the impact on the public of initially strict emission standards (and thereby high maintenance costs) is to arrive at the estimated failure rate incrementally. Thus, the failure rate of 40 percent could be established after an initial failure rate of 15 to 25 percent was applied during, say, the first year. This approach would give the public some additional time and flexibility with which to respond. In particular, cost of undertaking extensive maintenance could be spread over a longer period of time. One factor that must be considered, however, is whether an incremental approach would interfere with the Commonwealth's ability to meet federal standards within the required timetable for compliance.

An additional cost factor that merits consideration is the cost of time and personal inconvenience to vehicle owners, in particular to the 104,000 vehicle owners who would have to undertake mandatory maintenance, and then have their vehicles retested, assuming a 40 percent failure rate were applied. The time and personal inconvenience factor is even more significant if inspection is required on a semiannual basis. It is theoretically possible to apply a dollar cost per hour to the personal time required; however, selection of an appropriate dollar figure applicable to all income groups is problematic at best. Similiarly, application of a dollar amount to the personal inconvenience of the I/M procedure is equally difficult.* Approximately 2 (4) hours in total time would be required of all 260,000 owners for the annual (semiannual) vehicle emission inspection. An estimated 2 (4) hours additional time would be expended by the 104,000 vehicle owners for whom vehicle maintenance and retesting would be required annually (semiannually).

There are positive effects of an inspection/maintenance program which should be noted. Implementation of an inspection/maintenance program does offer significant offsetting benefits to the public. In addition to the highly positive health and welfare effects that would result from reduced levels of hydrocarbons and carbon monoxide, an I/M program could result in improved gasoline fuel economy, producing up to a 10 percent energy savings. Better tuned, better maintained vehicles with reduced misfiring and improved engine ignition could result in both reduced engine emissions and in an estimated fuel savings of 5 to 10 percent per vehicle. For purpose of analysis, it is assumed that the average driver drives 10,000 miles per year in a vehicle with average fuel consumption of 14 miles per gallon. On this basis, 714 gallons of gasoline would be consumed per vehicle per year. If better maintenance produced a 5 percent fuel savings, each driver would save 36 gallons of gasoline per year, or an annual total of 9.4 million gallons for the AQSA. At a cost of 58 cents per gallon, the per capita saving would be $21.00, or, a savings of $5,430,000 across the AQSA's vehicle population of 260,000. A savings of $21.00 per capita would significantly offset the $25.00 to $30.00 cost of emission-related maintenance, in addition to producing significant positive effects in terms of energy conservation. An associated effect would be a significant slowing down of the annual rate of growth in the demand for gasoline energy.

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*For a discussion of this problem, see Schwartz, S. I., Reducing Air Pollution by Automobile Inspection and Maintenance, J. of the Air Pollution Control Assoc., Vol. 23, No. 10, October 1973.

An additional positive effect that should be noted is the potential for accident reduction that could result from having better maintained and thereby safer vehicles in operation. This result is particularly characteristic of a vehicle safety inspection component of an inspection and maintenance program. Based on 1972 data from New York, automobile accident costs in New York accounted for $3 billion, 6 to 17 percent of which was attributable to safety defects. If an intermediate value of 11 percent is assumed, safety defects accounted for $330 million. If half of these defects had been detected and corrected, presumably $165 million could have been saved. If the AQSA were to obtain a proportional potential savings, a yield of about $2,500,000 a year would be realized.

In summary, the social effect of an Inspection/Maintenance Program on Springfield AQSA residents would be to increase the maintenance cost component of automobile ownership. The effect would be socially regressive, in that low income residents would be affected to a greater degree than would higher income residents. Positive effects that would offset this impact are decreased expenditures for gasoline, decreased incidence of safety-related accidents, and decreased health and welfare effects attributable to high ambient levels of transportation related pollutants.

Economic Impact

The discussion of economic impacts focuses upon two areas: economic costs to the state in terms of capital expenditure and annual operating costs; and economic impact upon the automotive industry.

The estimated capital and operating costs associated with two alternative I/M program configurations are presented in Tables IV-26 and IV-27. These configurations are: (1) Private licensed stations, and (2) State-run inspection stations.

A cost analysis for the Private Licensed Station approach is presented in Table IV-26. This approach assumes that some 1,600 of the over 4,700 stations currently performing safety inspection statewide would be designated and licensed by the Commonwealth to conduct emissions and safety inspection. An estimated one tenth of these stations would be within the Springfield AQSA. Licensed stations would individually expend between $1,800 and $6,020 for emissions inspection equipment,* and up to $20,000 for safety inspection equipment. According to proposed requirements for state licensing, stations would be required to staff and set aside a 450 square foot area within their main building for the purpose of performing I/M program-related activities at least 9 hours per day. The major responsibilities of the Registry of Motor Vehicles under this approach would be to make periodic checks on individual stations for

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*Depending upon the level of accuracy and type of equipment certified as acceptable by the Commonwealth.

Table IV-26. PRELIMINARY COST ESTIMATE - PRIVATE LICENSED STATION SAFETY AND EMISSION INSPECTION PROGRAM

Cost element	Cost
I. Capital costs:	
Land acquisition	-
Construction	-
Equipment[a]	$(11,800) $(1,800 per station, private purchase, emissions-related; $10,000 per station, private purchase, safety related)
II. Operating costs (annual):	
Labor[b]	$ 54,000
Supplies and maintenance	5,000
Training and certification[c,d]	24,000
Administration[e,f]	62,000
Insurance	-
Annual depreciation of capital	-
Total additional annual operating cost to state	$145,000 (10% Springfield AQSA only = $14,500)
Cost per vehicle tested[g]	$5.00

[a] Assumes purchase of simplest type of CO, HC analyzer, and safety testing equipment including headlight tester and hydraulic lift.

[b] Four supervisors at $13,500/year each

[c] Source: TRW. Socioeconomic Impact of Proposed Transportation Control Plans. For: U.S. Environmental Protection Agency

[d] Forty inspectors at $600 each

[e] Based upon discussions with Mr. Hourihan, Mass. Registry of Motor Vehicles

[f] Ten support staff at $6,200/year each

[g] Additional cost to state per vehicle: $0.25 (approx). Cost per vehicle to private station: $2.00 for equipment cost recovery, $2.75 for labor and overhead.

Table IV-27. PRELIMINARY COST ESTIMATE - STATE-RUN EMISSION INSPECTION PROGRAM

Cost element			Cost	
I. Capital costs:				
Land acquisition				$ 36,500
Three two-lane stations at $6,750[a]			$ 20,250	
Three single-lane stations at $5,400[b]			16,200	
Construction[c]				258,000
Three two-lane at $50,000[d]			150,000	
Three single-lane at $36,000[e]			108,000	
Equipment				135,500
Two-lane	Instrumentation at	$11,870		
	Automation, computer at	14,850		
	Total per station	$26,720		
Single-lane	Instrumentation at	$ 7,020		
	Automation at	11,405		
	Total per station	$18,425		
Total capital costs (Springfield AQSA only)				$430,000
II. Annual operating costs:				
Labor				$276,300
Two-lane	5 inspectors at	$10,500/annum		
	2 clerks at	6,200/annum		
	Total per station	$64,900/annum		
Single-lane	2 inspectors at	$10,500/annum		
	1 clerk at	6,200/annum		
	Total per station	$27,200/annum		
Maintenance and supplies[f]				17,820
Two-lane	$3,240 per station			
Single-lane	2,700 per station			
Training and certification				-
Administration (10% of):				11,850
1 program director at $16,000 per annum				
3 technical support staff at $13,500 per annum				
10 central clerical staff at $6,200 per annum				
Total, annual operating costs				$305,970
Annual depreciation of capital $429,885 at 10 percent for 10 years				47,290
Total, annualized cost				$353,260
Cost per vehicle				$1.40

[a] 15,000 sq ft at $0.45 sq ft, each

[b] 12,000 sq ft at $0.45 sq ft, each

[c] Estimate is exclusive of engineering and architectural fees

[d] 1,800 sq ft at $20/sq ft, each

[e] 1,800 sq ft at $20/sq ft, each

[f] Based on Arizona station estimates, plus $300 addition for utilities

the purpose of calibrating equipment, spot-checking the application of emission standards, and evaluating the adequacy of diagnostic and repair capability. In addition, the Registry would conduct a training and certification course for its own personnel involved in the program, at a cost of $600 per trainee. The Registry would also be responsible for administrative aspects of the program. Based on conversations with Registry personnel, it is likely that no additional inspectors would be required to make periodic station checks. Additional manpower that would be required includes four supervisory personnel, and 10 additional administrative and clerical personnel. Average salaries for additional staff are assumed to be $14,500 for supervisory and $6,200 for clerical personnel. On this basis, the annual cost to the state for a private licensed station emissions inspection program would be $145,000. Cost per vehicle tested would be $7, due mainly to the high cost of safety inspection test equipment, labor and overhead.

The capital and operating costs associated with State-run Inspection Program are presented in Table IV-27. The State-run inspection configuration assumes as a base estimate that six inspection facilities, with a total of nine inspection lanes, would be required to do emission testing within the Lower Pioneer Valley.* Stations would be located in each of the three counties: Franklin, Hampden, and Hampshire. A preliminary estimate is that each county would require one two-lane and one single-lane facility. (Although idle mode testing is used for the basis for this estimate, it should be noted that once the decision is made to conduct a state-run program and to undertake the capital investment in state facilities, the marginal cost of loaded mode testing equipment is small relative to the total cost of the program. Loaded mode testing could require either extended hours of operation or an additional inspection lane, given the slightly longer time required to perform the loaded test procedure.) Land acquisition and construction costs are estimated to be $294,500. Emission inspection equipment costs, assuming an automated and more precise instrumentation system than would be used in licensed private garages, are estimated at $135,500. On this basis, the total capital cost for the state run system within this AQSA is $430,000. Annual operating costs, consisting chiefly of salaries, are estimated to be $305,970, exclusive of annual capital depreciation. Total annual operating expenses, including capital depreciation, are $353,260, or $1.40 per vehicle.

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*This estimate assumes that inspection stations would be in operation 2,808 hours per year (8:00 to 5:00, or 9 hours per day, 6 days per week, 52 weeks per year). Assuming 4 minutes per vehicle for the test procedure (2 minutes for idle testing, 2 minutes dump time), annual lane capacity is 42,120 vehicles. This estimate allows for testing of 364,000 vehicles - 260,000 initial tests and 104,000 re-tests, assumming a 40 percent failure rate. If both emission and safety inspection were done in the State-run Inspection facility, annual lane capacity would be 8,424 vehicles, in that approximately 20 minutes would be required per vehicle inspection. At this rate, over 20 inspection stations would be required within the Springfield AQSA only at a capital cost of approximately $100,000 per station. In view of the prohibitively high costs associated with both safety and emission inspection in state-run stations, it has been assumed that only emission testing would be done in these facilities.

It should be noted that the state-run inspection configuration cost estimate pertains to the implementation of a staggered annual inspection program within the Springfield AQSA only. A statewide program would cost approximately 10 times this amount. Similarly, a program requiring semiannual inspection would require twice as many stations, thus approximately doubling the cost of the program.

A summary of the characteristics of these two programs is found in Table IV-28.

Table IV-28. SUMMARY: TWO I/M PROGRAM CONFIGURATIONS (SPRINGFIELD AQSA COSTS ONLY)

Element	Private	State run
Number of stations	160	6
Number of lanes	-	9
Capital costs	-	$430,000
Annual operating costs	$14,500	$305,970
Annualized cost	$14,500	$353,260
Cost per vehicle	$5.00	$1.40
Manpower required	14	44

As funding may be a formidable obstacle, even under the private licensed station approach, the Commonwealth should investigate financial mechanisms available to it to offset costs. As mentioned in the preliminary discussion, some states are considering a state-franchised program configuration under which capital costs for land acquisition, construction, and equipment - as well as personnel and other operating costs - would be the responsibility of a private contractor. With this configuration, program costs are generally shifted directly onto the public, in that the vehicle inspection fee is set sufficient to cover cost and provide contractor profit. If a franchise approach is recommended, the state should consider the potential applicability of state industrial development bonding. In essence, such bonding provides an interest subsidy to the contractor and thereby reduces the cost to the contractor of amassing capital required to get the capital construction phase of the program under way. The Commonwealth should also consider using state-owned or acquired sites as potential locations for inspection stations. State assistance in both locating and acquiring inspection centers could reduce both the time and cost of the initial planning and implementation phase of the program.

In view of the large amount of funding required for an Inspection/Maintenance Program, it is expected that Massachusetts will be required to seek outside financial assistance - either in the form of private funding from a private contractor, or federal financial assistance. Federal funding now available for Inspection/Maintenance is limited, however. Administrative costs incurred by the state's air pollution control agency for setting up an Inspection and Maintenance Program that are included in the agency's operating budget are potentially eligible for matching funds through EPA's grant program to support air pollution control agencies. Under the Manpower Development and Training Act, Federal funds can be obtained for the training of inspectors and/or mechanics to carry out the I/M Program. The potential sources of funding for setting up the program are the National Transportation Safety Act (Section 402) through which 50-50 funding is available for safety programs, and the Motor Vehicle Information and Cost Savings Act of 1972. Under Title III of this Act, the National Highway Traffic Safety Administration is authorized to establish a series of diagnostic auto inspection demonstration projects to provide accurate information on the cost of repairs to safety and emission items which fail to pass inspection. Five states have already received grants under this program.

Economic Impact on Automotive Industry

Tables IV-29 to IV-32 indicate the relative importance of the automotive industry to total employment in Massachusetts and in the Springfield AQSA. In 1973, some 121,483 jobs - or 6 percent of total state employment - were related to the automotive industry. Total reported payroll in automotive-related jobs was $254.2 million, and automotive establishments accounted for 11 percent of all employment establishments.

Table IV-29. COMMONWEALTH OF MASSACHUSETTS AUTOMOTIVE INDUSTRY 1973

	Category (SIC code)	Employees	Payroll (000)	Establishments
371	Motor vehicle and motor vehicle equipment manufacturing	6,199	$ 18,695	51
41	Local and suburban transit and interurban highway passenger transportation	19,522	36,131	854
42	Motor freight transportation warehousing	26,632	70,588	1,911
47	Transportation services	3,814	7,215	394
501	Wholesale motor vehicles and automotive parts and supplies	10,318	24,325	733
55	Retail automotive dealers and gasoline service stations	41,831	75,625	4,914
75	Automotive repair, services and garages	13,167	21,656	2,098
	Automotive total	121,483	$ 254,235	10,955
	Industrial total for Massachusetts	1,960,161	3,891,030	102,347
	Percent automotive of industrial total	6%	7%	11%

Source: U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of Census. County Business Patterns.

Table IV-30. HAMPDEN COUNTY AUTOMOTIVE INDUSTRY 1973

	Category (SIC code)	Employees	Payroll (000)	Establishments
371	Motor vehicle and motor vehicle equipment manufacturing	0	$ 0	0
41	Local and suburban transit and interurban highway passenger transportation	1,115	1,576	40
42	Motor freight transportation warehousing	2,434	6,664	148
47	Transportation services	237	390	27
501	Wholesale motor vehicle and automotive parts and supplies	821	1,629	63
554	Gasoline service stations	(1,517)	(1,510)	(268)
55	Retail automotive dealers and gasoline service stations	3,437	5,823	402
753	Automotive repair shops	(663)	(1,348)	(120)
75	Automotive repair, services and garages	1,010	1,624	165
	Automotive total	9,054	$17,706	845
	Industrial total for Massachusetts	147,587	274,028	7,797
	Percent automotive of industrial total	6%	6%	11%

Table IV-31. HAMPSHIRE COUNTY AUTOMOTIVE INDUSTRY 1973

Category (SIC code)		Employees	Payroll (000)	Establishments
371	Motor vehicle and motor vehicle equipment manufacturing	0	$ 0	0
41	Local and suburban transit and interurban highway passenger transportation	197	161	19
42	Motor freight transportation warehousing	219	415	26
47	Transportation services	0	0	0
501	Wholesale motor vehicles and automotive parts and supplies	853	1,745	59
554	Gasoline service stations	(359)	(321)	(73)
55	Retail automotive dealers and gasoline service stations	936	1,380	110
753	Automotive repair shops	(158)	(250)	(42)
75	Automotive repair, services and garages	183	278	48
	Automotive total	2,388	$ 3,979	262
	Industrial total for Massachusetts	27,097	45,129	1,772
	Percent automotive of industrial total	9%	9%	15%

Table IV-32. FRANKLIN COUNTY AUTOMOTIVE INDUSTRY 1973

Category (SIC code)		Employees	Payroll (000)	Establishments
371	Motor vehicle and motor vehicle equipment manufacturing	0	$ 0	0
41	Local and suburban transit and interurban highway passenger transportation	0	0	0
42	Motor freight transportation warehousing	211	500	30
47	Transportation services	0	0	0
501	Wholesale motor vehicles and automotive parts and supplies	164	387	6
554	Gasoline service stations	(157)	(185)	(51)
55	Retail automotive dealers and gasoline service stations	487	858	78
753	Automotive repair shops	(44)	(74)	(16)
75	Automotive repair, services and garages	71	100	21
	Automotive total	933	$1,845	135
	Industrial total for Massachusetts	15,050	27,080	1,046
	Percent automotive of industrial total	6%	7%	13%

Within Hampden, Hampshire, and Franklin Counties, the three counties within the Air Quality Study Area, automotive-related jobs accounted for 6 to 9 percent of total employment, 6 to 9 percent of earnings, and from 11 to 15 percent of all employment establishments.

Creation of an Inspection/Maintenance Program would infuse millions of dollars in repair-related expenditures into the automotive industry. Assuming, for purpose of analysis, a 40 percent failure rate were applied to the emissions inspection, an estimated $3.12 million would be expended for emission-related repairs in the three-county area. The effect of such expenditure would be the creation of several hundred new jobs within the automotive industry, in particular within automotive repairs, services, and garages. Emission-related repair expenditures alone could potentially create an estimated 200 new jobs, in addition to infusing large amounts of capital into the business economy. According to the manpower estimates contained in Table IV-28, the inspection phase of the program would create between 14 to 44 new jobs in addition to those generated through maintenance expenditures. Most of these new employees would be recruited from the state's socioeconomic strata most troubled by unemployment.

The demand generated by an I/M Program for automobile repair services would place a severe burden on the ability of existing repair establishments to accommodate repair demand. Within the three-county area, there was roughly one mechanic for every 200 vehicles. If private garages were licensed to perform emissions (and safety) inspection in addition to performing repairs - as would be required under the private licensed station - the burden on private garage and repair facilities would be even greater. While it would be possible for the industry to accommodate the demand for repairs over a 1 to 2 year lead time, it would be more difficult to accommodate the demand for both inspection and repairs within that time.

The extent to which individual private inspection stations would be permitted to recover the cost of emission inspection equipment would depend upon the fee charged for inspection. As can be seen in the previous tables, this analysis assumes that the inspection fee would be set so as to allow individual stations to recover equipment and overhead costs on a per car basis. The estimated private station cost recovery rate is $6.75 per car, assuming $4.75 toward inspection equipment and $2.00 toward manpower and overhead.

In summary, an emissions inspection and maintenance program would have a highly positive effect on the automotive industry as a whole, and upon individual repair establishments. An estimated 200 new jobs would be created in repair facilities as a direct result of the demand for emission-related maintenance.

REFERENCES

1. GCA/Technology Division. Development and Evaluation of Transportation Control Plans for Connecticut. Draft Proposed Transportation Control Plan. Volume I. For: U.S. Environmental Protection Agency, Boston, Mass. March 1975.

2. Coordinating Committee on Air Quality Studies. National Academy of Sciences, National Academy of Engineering. Air Quality and Automobile Emission Control. Volume 4. The Costs and Benefits of Automobile Emission Control. For: Committee on Public Works, United States Senate. U.S. Government Printing Office. Washington, 1974. 470 pp. Serial No. 93-24.

3. Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources. U.S. Environmental Protection Agency, Standards and Engineering Division. September 1974.

4. Hydrocarbon Pollutant Systems Study. MSA Research. October 1972.

5. 40 FR 25151, June 12, 1975.

6. Legal and Institutional Issues of Carpooling. U.S. Department of Transportation. January, 1974.

7. Wilbur Smith and Associates. Transit Improvement Program for the Lower Pioneer Valley, Massachusetts. For: Lower Pioneer Valley Regional Planning Commission. 1972.

8. Parking Principles. Highway Research Board, National Academy of Sciences, National Academy of Engineering. Washington, D.C. Special Report 125. 1971.

9. U.S. Department of Transportation, Federal Highway Administration. Manual on Uniform Traffic Control Devices. U.S. Government Printing Office, Washington, D.C. American National Standards Institute Standard #D6.1-1971. 1971.

10. Inspection and Maintenance: A Guide for Implementation. U.S. Environmental Protection Agency, Strategies and Air Standards Division. February 1974.

11. Control Strategies for In-Use Vehicles. U.S. Environmental Protection Agency, Office of Air and Water Programs. Washington, D.C. November 1972.

SECTION V

COMBINED CONTROL MEASURES

GENERAL

Section IV discussed each of the several proposed control measures in terms of individual socioeconomic impact and effectiveness. This section, in contrast, will present the cumulative impacts of the entire proposed Transportation Control Plan. The net effects may not be simply the sum of the effects of individual component measures because, in some cases, the components overlap in effectiveness and in other cases the component measures complement each other.

IMPACT OF CONTROL MEASURES

Social and Economic Impacts

The social and economic impacts of the control measures are highlighted in Table V-1. Transit improvements were omitted from the table becuase these are to be undertaken independently of the TCP. In aggregate, the social impacts of the measures are favorable, with reduced automotive expenses and gasoline savings being the most prominent. The economic impacts are primarily the costs associated with implementing the various measures. Important fuel savings result from several measures, benefitting both individuals and society as a whole.

As can be seen from the table, some of the social and economic costs have not been quantified. The reader is referred to the narrative discussion

Table V-1. SOCIAL AND ECONOMIC IMPACTS OF THE TRANSPORTATION CONTROL MEASURES

Measure	Social impacts	Economic impacts
Stationary source controls	Some higher prices for goods and services	Capital cost of controls: vary by industry; also see Volume II. Reformulation: in some instances may increase operating cost.
Carpooling matching system	Gasoline savings: up to 3.7 million gallons per year in AQSA[a] Reduced automotive expenses: variable costs reduced by up to $4.5 million/year in AQSA[a]	Highly variable depending upon incentives selected by employers; generally modest costs for incentives, offset by reduced costs for parking facilities.
Traffic flow improvements	Increased parking cost Increased costs for violators Possible reductions in travel costs, accident costs.	Capital cost: $147,000 Meter revenue loss: $23,700 Manpower costs: $20,000 Possible business inconvenience due to delivery restrictions
Inspection and maintenance[b]	Fee: $1.3 million of annual inspection $2.6 million if semi-annual inspection Repairs: $3.12 million if annual inspection $6.24 million if semi-annual inspection Gasoline savings: $5.46 million (9 million gallons)	Employment increase Capital and operating costs are covered and therefore reflected by the fee charged

[a] Based upon analysis in Appendix K. Assumes carpooling goal is met. Assumes 15 mpg, $0.08 per mile operating cost.

[b] Annual costs for entire AQSA.

in Section IV for the further explanation of these instances and for discussion of transit improvements.

Travel Impact

The control strategies recommended for implementation do not tend to restrict travel, per se, although several measures are aimed at shifting travel mode and reducing unnecessary random circulation (mainly in the Springfield central business district). In particular, the recommended improvements in transit service and the carpool matching program have good potential to effect changes in mode selection that would result in a reduction of vehicle-miles of travel (VMT) by light-duty vehicles. From a regional perspective these reductions in VMT will be modest (estimated to be a maximum of 2.7 percent reduction in total VMT); these reductions will be more significant because they will occur in the more densely populated portions of the AQCR and their impact will include reducing traffic volumes on major arterial streets. Therefore, benefits (reduced congestion, delays, etc.) will also accrue at the local level because of these measures. It is estimated that average daily traffic (ADT) volumes on several important arterials in downtown Springfield could be reduced by about 1500 to 2000 vehicles per day with the improved transit system and an effective carpool matching program.

Average travel speeds regionwide would not be affected significantly by any of the proposed measures. Increased average travel speeds are expected, however, on various streets in downtown Springfield as a result of changes in the circulation patterns, decreased intersectional and marginal friction, and spot reductions in traffic volumes. The predicted speed and volume characteristics of the downtown street network, assuming implementation of all strategies, are compared with the existing characteristics in Appendix F.

Air Quality Impacts of Combined Strategies

Oxidants - The cumulative effect of all control measures proposed to reduce reactive hydrocarbon emissions, including vehicular and stationary source controls, is presented in Table V-2. From Table V-2 it can be seen that application of all measures would result in a total reduction of 34,242 kilograms of hydrocarbon emissions per day. This reduction represents 37.8 percent of the expected uncontrolled (except for FMVECP) daily emissions of 90,496 kilograms by 1 August 1976. (The carpool program was excluded from the table because the magnitude of its effect will depend upon the degree of employer effort and is thus difficult to estimate accurately.)

In Section III the presumed allowable rate of reactive hydrocarbon emissions was calculated and found to be 57,700 kilograms per day. Comparing the allowable emissions rate with the estimated emissions rate for 1 August 1976 (assuming all stationary and mobile source controls are in effect) it can be seen that the required reduction in hydrocarbon emissions is achieved with a slight factor of safety. Daily emission rates for selected years through 1985 are shown in Table V-3.

The analysis presented in Tables V-2 and V-3 presumed that the relevant control measures will be fully in effect on 1 August 1976. That date was used for analysis of oxidants in the draft report, for consistency with the CO analysis. The attainment date for meeting the National Ambient Air Quality Standard for oxidants in the Springfield AQSA is legally 31 May 1975, because no extension has been requested of EPA. It was clear at the time of preparing the draft that that date would not be met; the attainment date for the CO standard (1 August 1976) was therefore used.

It now appears possible, however, that the oxidants standard may not be attained by 1 August 1976. As was discussed in Section IV and as will

Table V-2. COMBINED STRATEGY EFFECTIVENESS IN REDUCING REACTIVE HYDROCARBON EMISSIONS IN FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emissions source category	Emissions source	Control concept	Estimated 1 Aug. 1976 emissions[a]		Emissions reduction achieved, kg/day	Reduction achieved as a percentage of source emissions, %	Reduction achieved as a percentage of total HC emissions, %
			Without[b] controls, kg/day	With proposed controls, kg/day			
Vehicular sources	Light-duty vehicle	Inspection and maintenance[c]	28,733	27,009	1,724	6.0	1.9
	Light-duty trucks	Inspection and maintenance[c]	7,704	7,180	524	6.8	0.6
	All other vehicles	None	10,157	10,157	–	0.0	0.0
Subtotals			46,594	44,346	2,248	4.8	2.5
Nonvehicular sources	Dry cleaning	Reformulate	194	0	194	100.0	0.2
	Degreasing	Reformulate	552	26	526	97.1	0.6
	Surface coating	Vapor recovery and control	29,060	6,058	23,002	79.2	25.4
	Manufacturing	Vapor recovery and control	2,913	680	2,233	76.7	2.5
	Bulk petroleum storage	Vapor recovery	326	226	100	30.7	0.1
	Fuel combustion	None	2,203	2,203	0	0.0	0.0
	Solid waste incineration	None	806	806	0	0.0	0.0
	Gasoline marketing	Vapor recovery and control	6,598	659	5,939	90.0	6.6
	Aircraft, LTD's	None	142	142	0	0.0	0.0
	Railroad and vessels	None	1,108	1,108	0	0.0	0.0
Subtotals			43,902	11,908	31,994	72.9	35.4
Totals			90,496	56,254	34,242	37.8	37.8

[a] Reactive hydrocarbon emissions only.

[b] With FMVECP only.

[c] Assumes idle mode, annual inspection interval, 40 percent failure rate; this is the most conservative configuration of inspection and maintenance analyzed and the one most likely to be implemented. Table assumes I/M would be fully effective by 1 August 1976 (i.e., that inspections began in August 1975).

Table V-3. PROJECTED REACTIVE HYDROCARBON EMISSIONS FROM ALL SOURCES ASSUMING RECOMMENDED CONTROL MEASURES ARE IN EFFECT, FOR FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

Emissions source	Projected emissions assuming proposed controls are in effect, kg/day				
	1975[a,b]	1976[c]	1977[a]	1980[a]	1985[a]
I. Vehicular sources:					
Light-duty vehicles	30,041	27,003	24,465	20,218	17,958
Light-duty trucks	7,910	7,180	6,879	5,242	4,381
Heavy-duty vehicles	6,749	6,566	6,177	4,967	3,632
Motorcycles	196	196	196	197	201
Light-duty diesel vehicles	4	4	4	5	5
Heavy-duty diesel vehicles	3,329	3,391	3,541	3,327	4,348
Subtotal	48,229	44,346	41,262	33,956	30,525
II. Nonvehicular sources:					
Dry cleaning	204	0	0	0	0
Degreasing	542	26	17	17	25
Surface coating	28,364	6,058	7,909	8,443	9,524
Manufacturing	2,871	680	713	800	947
Bulk petroleum storage	330	226	219	201	179
Fuel combustion	2,155	2,203	2,237	2,369	2,602
Solid waste incineration	803	806	815	833	862
Gasoline marketing	6,691	659	636	589	519
Aircraft, LTO's[d]	137	142	154	184	246
Railroad and vessels	1,086	1,108	1,163	1,290	1,531
Subtotal	43,183	11,908	13,863	14,726	16,435
Totals	91,412	56,254	55,125	48,682	46,960

[a] As of 31 December.

[b] Assumes only FMVECP.

[c] As of 1 August.

[d] Landings and takeoffs.

Note: See Section III for discussion on the derivation of the data.

be shown in Section VI, the Inspection/Maintenance program is unlikely to have any effect on emissions until at least late 1976, because inspections are not scheduled to begin until August 1976 (in the Boston area). By inspection of Table V-2, it can be seen that the allowable emissions rate of 57,700 kg/day will be exceeded on 1 August 1976 if I/M is not in effect by then, unless other measures are instituted.

The carpooling program, if fully in effect by 1 August 1976, could reduce vehicular emissions by about 2.7 percent (maximum) or 1200 kg/day. In that event, total emissions would be about 57,300 kg/day, or just barely under the calculated allowable rate. As discussed in Appendix K, it is questionable whether that maximum carpooling effectiveness should be relied upon in order to achieve standards; the program's effectiveness will depend upon whether it is mandatory and upon its timing.

In the event that a later attainment date than 1 August 1976 is chosen for oxidants, the increasing effect of FMVECP will reduce the amount of emission reduction that must be achieved by local control measures such as I/M or carpooling. Table V-4 shows the emissions control that will be achieved on various dates, assuming that I/M inspections begin on 1 August 1976, as required for Boston. The table shows that I/M plus controls on nonvehicular sources (plus FMVECP) would reduce emissions to the allowable level (57,700 kg/day) by some time between 1 August 1976 and 31 December 1976. An effective carpooling effort would allow an earlier attainment date as indicated previously.

It should be noted that terms such as "safe emissions rate" or "allowable emissions rates" are not intended to imply the existence of an absolute upper limit of emissions that would guarantee that oxidant concentrations anywhere in the AQCR would not exceed the National Ambient Air Quality Standard. In the context of this report, the terms "safe" or "allowable" emissions rate indicate a theoretical rate that assumes that the oxidant concentrations within the AQCR are wholly a function of precursors generated within the AQCR.

Table V-4. PROJECTED HYDROCARBON EMISSIONS ASSUMING INSPECTION/MAINTENANCE BEGINS IN AUGUST 1976

	Projected emissions of reactive hydrocarbons assuming Inspection/Maintenance begins August 1976, kg/day[a]		
	1 August 1976	31 December 1976	31 May 1977
Nonvehicular sources[b]	11,908	12,482	13,058
Vehicular sources, without I/M[c]	46,594	45,425	44,551
Total, without I/M	58,502	57,907	57,609
Reduction from I/M[d]	0	904	1,767
Net, with I/M[d]	58,502	57,003	55,842

[a] Assumes no effect from carpooling. Carpool program could reduce vehicular emissions by a maximum of 2.7 percent (see Appendix K).

[b] Assumes controls in effect as discussed in Section IV.

[c] FMVECP only in effect.

[d] Idle mode, annual inspection, 40 percent failure rate, beginning in August 1976.

Previous discussion indicated that oxidant concentrations reported for a particular area result from hydrocarbon emissions generated within that area plus transport of oxidants and precursors from upwind sources. In the Massachusetts portion of the AQCR, it is not likely that the entire oxidants problem is due to transport from upwind sources nor is it likely that oxidants and precursors generated within this area do not contribute to oxidant concentrations at locations downwind of the AQCR. The implications of transport are not that less stringent controls on emissions sources within the AQCR are appropriate, but rather that the scope of control plans should be expanded to include areas even larger than the AQCR's as they are currently defined. The "allowable emissions rate" is thus the best estimate now available of the degree of emissions reduction that is required.

Carbon Monoxide - The impact of the proposed controls on carbon monoxide concentrations in downtown Springfield will result mainly from changes in emission characteristics along individual streets; the emission characteristics will change as a result of a redistribution of traffic and improved efficiency of traffic flow. Estimated resulting air quality at the 20 locations in downtown Springfield was determined through use of the APRAC computer model described earlier; these estimates appear in Table V-5. The control strategies' impacts were reflected by changes in traffic data input to the model.

From Table V-5, it appears that by 1 August 1976 the National Ambient Air Quality Standard for 8-hour average concentrations of carbon monoxide can be achieved. It is important to emphasize again, however, that the values presented in this table are not absolute but rather may be considered representative values. These values were derived from baseline data which, in turn, were based on a particular meteorological condition and an assumed average traffic condition (see Section III).

As in the analysis of oxidants, Table V-5 assumes that Inspection/Maintenance is fully effective by 1 August 1976. For the reasons given

Table V-5. PROJECTED CARBON MONOXIDE CONCENTRATIONS AT 20 LOCATIONS IN DOWNTOWN SPRINGFIELD, MASSACHUSETTS, ASSUMING RECOMMENDED CONTROL MEASURES ARE IN EFFECT

Location	Projected highest 8-hour average concentrations of CO							
	1975[a,c]		1976[b,d]		1977[b,c]		1960[b,c]	
	Highest	Second highest	Highest	Second highest	Highest	Second highest	Highest	Second highest
1. State at Chestnut	5.88	5.85	8.58	8.56	6.93	6.90	4.13	4.11
2. State at Dwight	11.72	11.65	7.82	7.78	6.32	6.28	3.76	3.74
3. State at Main	11.01	10.95	3.04	3.03	2.46	2.45	1.46	1.46
4. W. Columbus at I-91 southbound off-ramp	8.60	8.54	8.29	8.26	6.70	6.67	3.99	3.96
5. W. Columbus at Memorial Bridge	8.37	8.32	8.10	8.06	6.55	6.51	3.89	3.87
6. W. Columbus at State	6.08	6.05	8.58	8.55	6.93	6.88	4.12	4.09
7. W. Columbus at Union	2.08	2.07	1.73	1.73	1.39	1.39	0.83	0.83
8. E. Columbus at Union	4.18	4.15	2.75	8.79	2.24	2.23	1.32	1.31
9. E. Columbus at State	7.47	7.41	8.82	8.79	6.52	6.48	4.42	4.41
10. E. Columbus at I-91 northbound on-ramp	7.02	7.00	8.93	8.90	7.21	7.17	4.30	4.28
11. E. Columbus at Vernon	9.49	9.44	8.03	7.99	6.49	6.46	3.87	3.85
12. E. Columbus at Worthington	5.12	5.10	8.10	8.07	6.54	6.51	3.89	3.88
13. E. Columbus at Liberty	1.70	1.70	3.35	3.33	2.70	2.68	1.61	1.60
14. Main at Hampden	5.25	5.24	2.88	2.87	2.32	2.31	1.38	1.38
15. Main at Hillman	15.87	15.78	3.36	3.35	2.71	2.71	1.62	1.61
16. Main at Vernon	14.63	14.52	2.11	2.10	1.70	1.69	1.01	1.01
17. Main at Union	7.24	7.22	6.01	5.99	4.86	4.83	2.89	2.86
18. Dwight at Worthington	7.77	7.74	2.20	2.18	1.78	1.76	1.06	1.05
19. Dwight at Harrison	5.24	5.23	4.39	4.37	3.55	3.53	2.11	2.10
20. Chestnut at Bridge	4.00	3.99	3.82	3.81	3.08	3.07	1.84	1.83

[a] Assumes only FMVECP.

[b] Assumes all strategies are in effect, including inspection and maintenance.

[c] As of 31 December.

[d] As of 1 August.

earlier, it now seems unlikely that I/M would have had any effect by that date. Additional analysis was therefore performed in order to identify the effect of the present schedule for implementing I/M. It is assumed in this analysis that the traffic flow improvements can be implemented by 1 August 1976.

Table V-6 shows the difference in CO concentrations resulting from I/M for various analysis dates. For each date, I/M is assumed to be fully effective on the given date; I/M then accounts for a reduction in emissions of about 9 percent (see Section IV). It can be seen that the 8-hour standard of 9 ppm is forecasted to be violated at several locations on 1 August 1976 if I/M is not in effect by then, but would not be violated if I/M were fully effective. By 31 December 1976, FMVECP would reduce emissions enough that without I/M the 9 ppm limit would be exceeded at only one location analyzed (East Columbus Avenue at I-91 on-ramp); with I/M, all locations would meet standards. The CO standard could not be met without I/M until sometime in 1977. If I/M inspections were to begin in August 1976, as required in the Boston area, about 40 percent of all cars would have been inspected by the end of the year. In such a case, the peak CO level would be about mid-way between the two values for 31 December 1976 given in Table V-5 for the cases with and without I/M. By inspection, it appears that the highest CO reading would be below the standard in that case; that is, the data indicate that the CO standard could be met by 31 December 1976 if I/M is begun in August 1976. In short, I/M will allow earlier attainment of the CO standard if inspections are begun sometime in 1976.

It should be noted that the calculations of CO concentrations do not fully account for observed seasonal variations in CO concentrations. Because CO levels tend to be highest in winter, it is possible that actual concentrations in, say, May or August would be lower than indicated in Tables V-5 and V-6; thus, standards may be achieved slightly earlier than the calculations indicate.

Table V-6. PROJECTED CARBON MONOXIDE CONCENTRATIONS AT 20 LOCATIONS IN DOWNTOWN SPRINGFIELD SHOWING IMPACT OF INSPECTION AND MAINTENANCE WITH TIME

Location	Projected highest 8-hour average concentrations of CO-ppm[a]					
	1 August 1976		31 December 1976		31 May 1977	
	With I&M	Without I&M	With I&M	Without I&M	With I&M	Without I&M
1. State at Chestnut	8.58	9.35	8.09	8.82	7.59	8.27
2. State at Dwight	7.82	8.52	7.38	8.04	6.91	7.53
3. State at Main	3.04	3.31	2.87	3.13	2.70	2.94
4. West Columbus at I-91 Southbound off-ramp	8.29	9.04	7.82	8.52	7.35	8.01
5. West Columbus at Memorial Bridge	8.10	8.83	7.64	8.33	7.19	7.84
6. West Columbus at State	8.58	9.35	8.09	8.82	7.61	8.29
7. West Columbus at Union	1.73	1.89	1.63	1.78	1.62	1.76
8. East Columbus at Union	2.75	3.00	2.60	2.83	2.45	2.67
9. East Columbus at State	8.82	9.61	8.14	8.87	7.47	8.14
10. East Columbus at I-91 Northbound on-ramp	8.93	9.73	8.42	9.18	7.92	8.63
11. East Columbus at Vernon	8.03	8.75	7.58	8.26	7.12	7.76
12. East Columbus at Worth	8.10	8.83	7.64	8.33	7.18	7.83
13. East Columbus at Liberty	3.35	3.65	3.16	3.44	2.97	3.24
14. Main at Hampton	2.88	3.14	2.71	2.95	2.55	2.78
15. Main at Hillman	3.36	3.66	3.19	3.48	2.99	3.26
16. Main at Vernon	2.11	2.30	1.99	2.17	1.87	2.04
17. Main at Union	6.01	6.55	5.67	6.18	5.26	5.73
18. Dwight at Worthington	2.20	2.40	2.08	2.27	1.95	2.13
19. Dwight at Harrison	4.39	4.79	4.14	4.51	3.89	4.24
20. Chestnut at Bridge	3.82	4.16	3.60	3.92	3.57	3.89

[a] Assumes all strategies in places except I&M where noted.

Section III presented a discussion regarding the discrepancy between measured and calculated carbon monoxide concentrations at the East Columbus Avenue (East Columbus at I-91 northbound ramp) monitoring station. It was generally concluded that the APRAC model underestimated concentrations at that monitoring site because it may not have accounted for the total affect of emissions from I-91. Further analysis using a different computer model (HIWAY) indicated that I-91 emissions contribute significantly to the carbon monoxide concentrations at the East Columbus Avenue monitoring site. The implication then is that perhaps the I-91/East Columbus Avenue/West Columbus Avenue corridor should be regarded as a single source in the analysis of air quality along East Columbus Avenue or West Columbus Avenue.

Table V-5 or V-6 can be used for comparing relative values of carbon monoxide concentrations at each location with and without the proposed control measures applied. The general impact on air quality at each location can be observed from Table V-5 by comparing concentrations estimated for 1975 with those for 1 August 1976 (1975 data assumes that no controls other than FMVECP have been applied while 1976 data assumes that all control measures are in effect). While these data represent conditions separated in time by 7 months, the general impact of the strategies still can be seen. Table V-5 shows these differences directly, for dates not in Table V-4. The data indicate that the very high concentrations experienced along Main Street would be reduced significantly while at other locations various shifts of lesser magnitude might also occur. Generally, the result of the proposed strategies is to reduce concentrations of CO at locations where person-exposure is the most severe (along Main Street). While a few locations are predicted to experience increased CO concentrations because of altered traffic patterns, these are locations where person exposure is judged less severe and standards are not expected to be violated. Comparisons of estimated air quality with and without the strategies for various dates in 1976, 1977, and 1980 can be made from Tables V-5 and V-6 and Table III-20.

SECTION VI

SURVEILLANCE PROCEDURES AND MILESTONE CHART

GENERAL

This section discusses the scheduling of the control strategy implementation process and the subsequent surveillance of the measures' impact within the AQCR.

CONTROL STRATEGY IMPLEMENTATION SCHEDULE

Several important issues must be considered in the establishment of implementation dates. Foremost is the compliance data established by the U.S. Environmental Protection Agency. For the Massachusetts portion of the AQCR, this data has been defined as 1 August 1976 for carbon monoxide, and 31 May 1975 for oxidants. The Clean Air Act permits extensions of the compliance data to be granted in certain instances where it can be shown that the necessary technology or alternatives will not be available in time to implement strategies which would provide the necessary reductions in pollutant concentrations. Such an extension is required for attainment of the oxidants standard in the AQCR, although a request for this extension has not been initiated. In this regard, estimates of the implementation dates for each strategy will be an important issue in both justifying an extension request and selecting a new compliance date. Accurately determining the feasible implementation dates for each strategy must involve various state officials and agencies owing to the complexity of issues involved in the implementation process (e.g., funding, program administration, technical considerations, etc.).

Secondly, in establishing implementation dates, the complementary nature of measures must be considered. Certain control measures must be implemented in parallel to assure that the intended objectives of each measure are achieved.

Figure VI-1 presents a schedule, in the form of a milestone chart, for implementation of the proposed control measures. The headings under each measure refer to key stages in the implementation process. The intent of the milestone chart is not to set rigid deadlines for accomplishing each element of the implementation process, but rather, it provides initial estimates of the practicability of implementation and an indication of implementation sequences.

SURVEILLANCE PROCEDURES

General

Three basic levels of surveillance are necessary to guarantee the effectiveness of the control strategies outlined previously. These levels are:

- Review of progress in implementing the control measures.
- Review of the impact of the control measures on VMT or traffic operating characteristics (for all vehicular controls), and reactive hydrocarbon emissions (for stationary source controls).
- Review of the impact of the control measures on air quality.

Responsibility within the Commonwealth for ensuring compliance with regulations resulting from the Transportation Control Plan lies with the Executive Office of Environmental Affairs (EOEA) (see note below). It is

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Note: Effective 1 July 1975, the Executive Office of Environmental Affairs will be a cabinet-level agency that will include the air pollution control functions of the present Department of Public Health. Air pollution control will be the responsibility of the Department of Environmental Quality Engineering within EOEA.

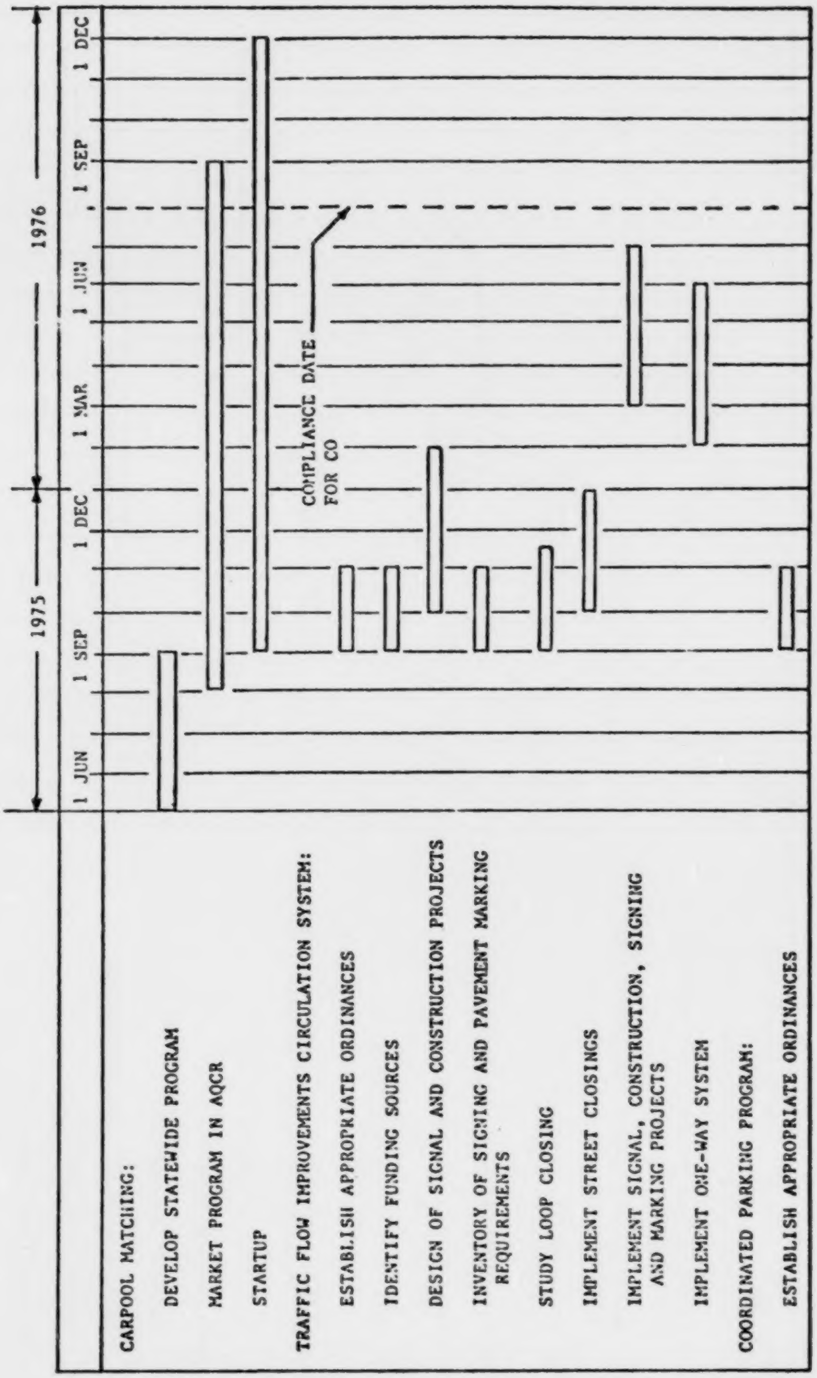

Figure VI-1. Milestone chart for implementation of control measures

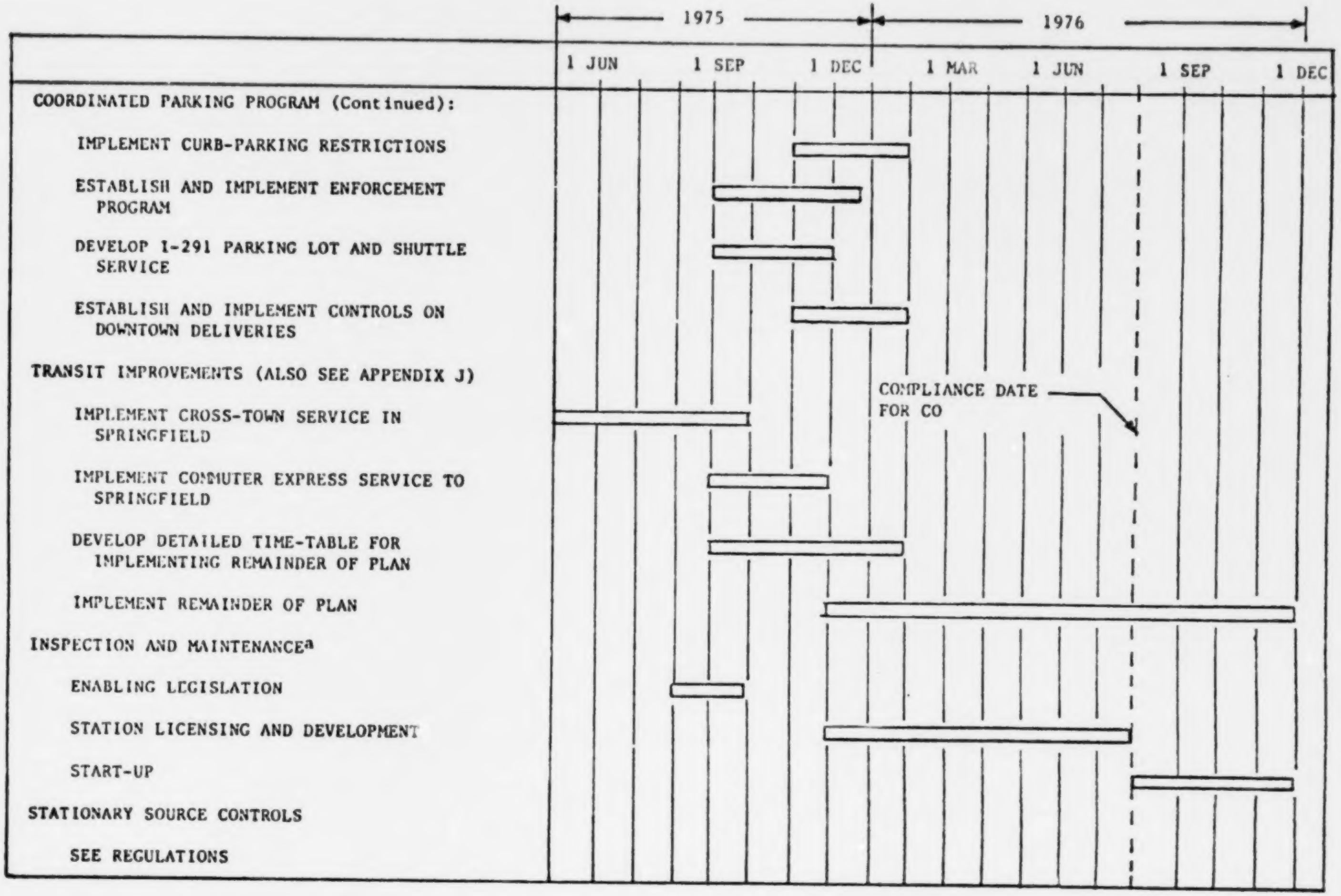

Figure VI-1 (continued). Milestone chart for implementation of control measures assumed, however, that other state agencies, such as the Department of Public Works and the Department of Public Health (see previous note), will be delegated responsibility for various aspects of the surveillance of control measures. The Lower Pioneer Valley Regional Planning Commission and other local agencies may also wish to become involved. A brief discussion for each of the three levels of surveillance is given below.

Review of Implementation Process

In order to ensure timely and coordinated implementation of control strategies, the step-by-step progress must be monitored and action taken where required to expedite implementation. An effective procedure for monitoring implementation progress would be to establish detailed time schedules and require periodic written reports on the actual progress being made by the agency overseeing the implementation of a particular control measure.

Review of the Impact of Control Measures

Once strategies have been implemented it is important to determine their effectiveness. For stationary source controls, this effectiveness can best be described in terms of the reduction in reactive hydrocarbons discharged to the atmosphere. The effectiveness of controls applied to motor vehicles, mainly inspection and maintenance, may require detailed analysis over a long period of time. Currently, inspection and maintenance has not been widely utilized, therefore detailed procedures for performing a practical periodic evaluation of the measures effectiveness have yet to be developed.

Measures affecting traffic operations can be evaluated utilizing any of several procedures. The simplest procedure is to report observations of the impact that a measure has had on traffic flow. While this method might have utility as an indicator of the general impact of a strategy, it is desirable to actually quantify the impacts by determining changes in travel speed, delay time, and traffic volumes throughout the street system. These types of data are usually obtained by state or city engineering departments. (Procedures for this type of evaluation have been developed by GCA for EPA; see Reference 1.)

Monitoring the direct effects of control measures can provide valuable information regarding the need to modify or delete strategies, or implement more stringent controls. Federal regulations, in fact, specify that emissions source data be collected and maintained to facilitate comparison of the planned and actual efficacy of control measures (40 CFR 51.19). The source surveillance requirements can be satisfied by implementing a program to update the data base which was developed by GCA for the evaluation of proposed control strategies. Surveillance requirements are outlined in the Proposed Regulations which appear in Appendix I.

Review of the Impact on Air Quality

The final result of any Transportation Control Plan is expected to be improved ambient air quality within the area affected by provisions of the plan.

In general, estimates of the impact of a strategy on carbon monoxide concentrations at individual locations can be made by comparing traffic volume and speed characteristics for the before and after conditions. These analyses, however, indicate only whether concentrations are likely to increase or decrease. To quantify the impact on individual locations, two options are available. First, concentrations can be measured directly through the use of portable monitoring instruments for both the before and after conditions; or, second, a computer model could be utilized to estimate the air quality based on actual traffic and meteorological data measurements (this technique was used in the development of strategies presented in this plan). The most acceptable method for assessing the impact of strategies on air quality would be to collect emissions source data, and meteorological data, and correlate these to air quality as determined by actual monitoring.

For oxidants, continuous monitoring will provide the best assessment of the effectiveness of strategies. It should be emphasized that only long-term monitoring will provide valid indications of the development of trends in air quality. Therefore, the evaluation of hydrocarbon emission controls will require considerable time to accomplish.

Federal regulations also require that the impact on air quality be determined through continued surveillance of pollutant concentrations (40 CFR 51.17). Because a monitoring program is currently in effect within the AQCR, it is expected that the surveillance requirements can be satisfied, assuming that the program is not reduced in scope or curtailed.

RECOMMENDATIONS FOR PLAN UPDATING

Based on data derived from the surveillance of both emission-source characteristics and air quality data subsequent to implementation of the control measures, the overall Transportation Control Plan (TCP) should be reviewed periodically and revised as warranted. It is considered that expansion of air quality monitoring programs in the AQCR as well as advances in the state-of-the-art of monitoring in general, will result in the identification of additional air quality problems and/or redefinition of existing problems, all of which will warrant revisions to the TCP. The implication is, then, that the TCP is but a first step in the overall process of air quality planning.

During the process of evaluating air quality for this report, it became obvious that important improvements to the data base could be achieved by implementing a coordinated program of data collection involving air quality, traffic, and meteorological parameters. Towards this end, the following actions are proposed as part of an effort to update the TCP; these should supplement the monitoring and surveillance requirements referred to in the proposed regulations (see Appendix I).

Air Quality Monitoring Program

A more extensive air quality monitoring program must be developed and maintained to ensure that all pollutant problems within the AQCR are identified. An essential element of this program would be the placement of ozone monitors at optional locations throughout the AQCR to measure maximum ozone levels from sources within the region and elsewhere. Also, additional carbon monoxide monitoring sites are needed, both temporary and fixed, to help define additional locations where controls are required as well as to monitor the results of control stragegies. Also, it was mentioned in Section III that, for this report, the analysis of carbon monoxide problems was limited to downtown Springfield even though it is possible that concentrations in certain other areas may exceed the standards. Because this possibility exists, a program should be established for both identifying possible carbon monoxide hot spot locations and developing control measures to reduce concentrations accordingly. Carbon monoxide hotspot regulations appear is Appendix I.

Monitoring Traffic Characteristics

There is an obvious need to develop and maintain a solid data base of traffic characteristics within the AQCR. On a regional basis, data relating to vehicle-miles of travel (VMT), travel speeds and vehicle classification should be developed utilizing sampling techniques since the area involved is far too large for comprehensive studies to be practical. Traffic data for more compact areas, such as the urban central business districts, should be developed in detail. Data elements that are most important include traffic volumes, distribution of traffic by vehicle type and age, and speed characteristics. Other types of data such as transit and parking inventories and usage characteristics, are appropriate also.

Meteorological Data

Meteorological data, particularly wind speed and direction; should be monitored at all present and future air quality monitoring stations within the AQCR. Other meteorological data should be monitored locally, or at least within the AQCR. Currently, upper air data are obtained from a weather station located in Albany, New York.

Interfacing Data

It was emphasized in Section III of this report that ambient concentrations of carbon monoxide are a very localized phenomenon, yet in analyzing the measured concentrations for a particular day various generalities must be assumed. This was exemplified in the discussion of the APRAC analysis of worst day carbon monoxide concentrations in Springfield; in the analysis average traffic conditions had to be assumed in a discussion of extreme air quality conditions. In all probability traffic conditions were not average on that particular day, however, this could not be substantiated owing to the lack of more explicit data.

To overcome this problem, it is recommended that several permanent traffic counting stations be installed in and around the Springfield central business district and at other locations within the AQCR as deemed appropriate. Also, it is recommended that traffic surveillance be accomplished in concert with air quality and meteorological monitoring at numerous temporary sites in the AQCR. Carbon monoxide monitoring should become a process involving not only the measurement of ambient air quality, but also measurement of meteorological and traffic conditions, as well.

REFERENCE

1. GCA/Technology Division. Measuring the Effectiveness of Transportation Controls. Case Studies. Final Report. For: U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711. February 1975.

APPENDIX A

MUNICIPALITIES IN THE MASSACHUSETTS PORTION OF THE HARTFORD-NEW HAVEN-SPRINGFIELD AIR QUALITY CONTROL REGION

Agawam
Amherst
Ashfield
Belchertown
Bernardston
Blandford
Brimfield
Buckland
Charlemont
Chester
Chesterfield
Chicopee
Colrain
Conway
Cummington
Deerfield
Easthampton
East Longmeadow
Erving
Gill
Goshen
Granby
Granville
Greenfield
Hadley
Hampden
Hatfield
Hawley
Heath
Holland
Holyoke
Huntington
Leverett
Leyden
Longmeadow
Ludlow
Middlefield
Monroe
Monson
Montague
Montgomery
New Salem
Northampton
Northfield
Orange
Palmer
Pelham
Plainfield
Rowe
Russell
Shelburne
Shutesbury
South Hadley
Southampton
Southwick
Springfield
Sunderland
Tolland
Wales
Ware
Warwick
Wendell
Westfield
Westhampton
West Springfield
Whately
Wilbraham
Williamsburg
Worthington

APPENDIX B

QUESTIONNAIRE ON AIR QUALITY MONITORING SITES

Following this page is a reproduction of the questionnaire sent by GCA to the Pioneer Valley Air Pollution Control District. Immediately following the questionnaire is a reproduction of the District's reply.

8 November 1974

AMBIENT AIR QUALITY DATA ANALYSIS

Questionnaire for State Air Quality Monitoring Department

1. No. of sampling sites in the State:
    a. Carbon Monoxide (CO):
    b. Photochemical oxidants (OX):
    c. Hydrocarbons (HC):
    d. Nitrogen oxides (NO_x):

2. For each sampling site(past and present):

    a. Location:

    Town or city
    Identification of building or other site (golf course, etc.)
    Fixed or mobile installation
    Environment - urban, suburban, or rural

    b. Exposure:
    Spatial orientation of probe: height of probe above surface; type of surface (paved, grass, etc.); distance in from curb (if a street-side installation) or distance from nearest road or highway (if in an open area); distance out from side of building or trailer side (if so mounted); orientation and width of street and height of buildings along the street (for urban locations); which side of building or trailer (direction facing)? (Exposure to prevailing wind)(or past)

    c. Length of period site has been in operation in its present/configuration (period of record); for discontinued sites or instruments, the reason for its discontinuance.

    d. Instrumentation:

    Type, make, and model of instrument, and year of manufacture. (Type is process used, such as NDIR for CO monitors, chemiluminescence for O_3 monitors, etc.)

    Operation - any problems in normal operation? Are these generic to this type/make, or do they seem to be unique to this particular instrument? - for the site, poor exposure? Poor access? Any vandalism? Weather? - with maintenance, frequency of calibration, any problems with span gas or maintenance supplies/equipment, adequacy of training program and level of personnel.

    e. Any comments on the data itself -- consistency, reliability, representative of highest expected concentrations? Quality control program to reduce errors in transcribing from original strip charts to tabulated numerical values, in copying the data on to the SAROAD Forms, into punched cards, etc.

3. Plans for future monitoring program - additional/different sites, indtrumentation, staff training programs, etc. Timing of these planned events? Are adequate funds provided in the State budget? If not, how much more is needed?

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best available copy.

The Commonwealth of Massachusetts
Pioneer Valley Air Pollution Control District
1111 State Street, Springfield 01109

TEL. 413-785-5327

March 25, 1975

Mr. Theodore P. Midurski
GCA/Technology Division
Burlington Road
Bedford, Massachusetts 01730

Dear Ted:

I believe the following information will answer your questions concerning our continuous ambient air sampling sites.

1. No. of Sampling Sites in the PVAPCD
   - a. Carbon Monoxide - 1
   - b. Photochemical Oxidants - 2
   - c. Hydrocarbons - 0
   - d. Nitrogen Oxides - 1
2. Sampling Sites
   Present Site 1
   - a. Location
     1. Springfield
     2. State trailer next to East Columbus Ave., between Elm and Court Streets
     3. Fixed Location
     4. Urban Environment
   - b. Exposure

     Vertical; 15 feet above surface; mostly grass; 25 feet from East Columbus Ave.; manifold exits vertically through trailer roof; enclosure No. 1 will give information about streets and surrounding buildings; prevailing wind is from south in summer and north in the winter.
   - c. Present site has been in operation since 11/4/72.
   - d. Instrumentation:

Type	Make	Model	Year of Manufacture
NDIR for CO	Intertech	---	1970 (original) 1972 (present)

Type	Make	Model	Year of Manufacture
Coulometric Titration for SO_2	Philips	PW9706	1972
Chemiluminescence for O_3	Monitor Lab	8410	1972
Chemiluminescence for NO_2	Bendix (Fed. Instr)	8101-B	1972

Operation of the instrumentation is satisfactory. There are no particular or generic instrumental problems and there are no particular site, weather, vandalism, supply or personnel problems. Specific questions could best be answered by Air Surveillance Section, Tewksbury Hospital, Tewksbury.

e. The recorded data is valid.

The strip chart for each instrument is read manually the first week of each month and the hourly readings are sent to Boston. The telemetered data is compared with the strip chart readings and the telemetered data is corrected if a discrepancy greater than the criteria value for a particular pollutant occurs. If telemetered data is believed to be correct, the strip chart readings will be checked. After the discrepancies have been answered, a correct printout is forwarded to the District. The quality control program employed by the Data Processing Section in Boston during data storage and retrieval is not known.

Present Site 2

a. Location

1. Amherst
2. Water Chemistry Lab, Western Mass. Public Health Center
3. Fixed location
4. Rural environment

b. Exposure

Horizontal: 30 feet above surface, mostly paved; 150 feet from North Pleasant Street, 3 feet from side of building. North Pleasant Street runs north - south and is 20 feet wide; probe extends from south side of building prevailing wind is from south in summer and north in winter.

c. Site became operational 8/27/74.

d. Instrumentation:

Type	Make	Model	Year of Manufacture
Chemiluminescence for O_3	Bendix	8002	----

Statement concerning operation of instrument and various problems is same as for preceeing instruments.

e. The recorded data is valid. The strip chart for this instrument is read manually on a bimonthly basis. The hourly readings are sent to Boston to be put in the computer for storage and processing. A computer printout is returned to the District. The printout is checked versus the hourly chart readings. If errors are found, the corrections are sent to Boston and a corrected printout is returned to the District.

Past Site 3

a. Location

1. Springfield
2. Steiger's Department Store on the corner of Main and Hillman Streets
3. Fixed location
4. Urban environment

b. Exposure

Horizontal; 20 ft. above surface paved surface 10 feet from Hillman Street, 4 feet out from side of building; enclosure No. 2 will give information about street and surrounding buildings; prevailing wind is from south in summer and north in winter.

c. This site began operation on 7/24/73, and it ceased operation 6/10/74, due to instrument problems.

d. Instrumentation:

Type	Make	Model	Year of Manufacture
NDIR for CO	MSA	LIRA 200	1971

Statement concerning operat on of instrument and various problems is same as for preceding instruments.

e. The recorded data is valid. The method of recording the data was the same as for the Bendix - O_3 Instrument in Amherst.

Past Site 4

a. Location

1. Springfield
2. Federal trailer next to East Columbus Ave. between Elm and Court Streets
3. Fixed location
4. Urban environment

b. Exposure

Information is same as listed for Present Site 1.

c. This site began operation on 9/3/71 and ceased operation 10/13/72 due to instrument problems and removal of federal trailer.

d. Instrumentation:

Type	Make	Model	Year of Manufacture
NDIR for CO	MSA	LIRA 200	1971
Chemiluminescence for O_3	Bendix	---	1971

Statement concerning operation of instruments and various problems is same as for preceding instruments.

e. The recorded data is valid. The method of recording the data was the same as for the Bendix - O_3 Instrument in Amherst.

Past Site 5

a. Location

1. Springfield
2. Basement in Jewish War Veterans' Building, 68 Court St.
3. Fixed location
4. Urban environment

b. Exposure

Spatial orientation of probe not known; height of probe above surface not known; paved surface 15 feet from East Columbus Ave.; distance out from side of building is not known, enclosure No. 1 and 3 will give information about streets and surrounding buildings, prevailing wind is from south in summer and north in winter.

c. Site began operation 3/4/70, and it ceased operation 12/14/70, due to instrument problems caused by water.

d. Instrumentation:

Type	Make	Model	Year of Manufacture
NDIR for CO	Intertech	---	1970

Statement concerning operation of instrument and various problems is same as for preceding instruments.

e. The data is valid. The specific method of recording the data is not known.

Past Site 6

a. Location

1. Springfield

2. Powerhouse for municipal buildings on East Columbus Ave.
3. Fixed location
4. Urban environment

b. Exposure

Vertical; 15 feet above surface; paved surface 10 feet from East Columbus Ave.; probe exited through roof vent and was extended to front of building where it was 4 vertical feet above roof; enclosure No. 3 will give information about streets and surrounding buildings; prevailing wind is from south in summer and north in winter.

c. Site began operation on 12/29/70 and ceased operation on 10/31/72, because instrument moved to state trailer.

d. Instrumentation:

Type	Make	Model	Year of Manufacture
NDIR for CO	Intertech	---	1970

e. The data is valid. It is believed that a method similar to that used for recording and verifying the Bendix - O_3 Instrument data in Amherst was used.

3. At a future and unknown date, a trailer will be located in Chicopee. The instrumentation will be identical to that located in the Springfield trailer. Much of the equipment has already been purchased.

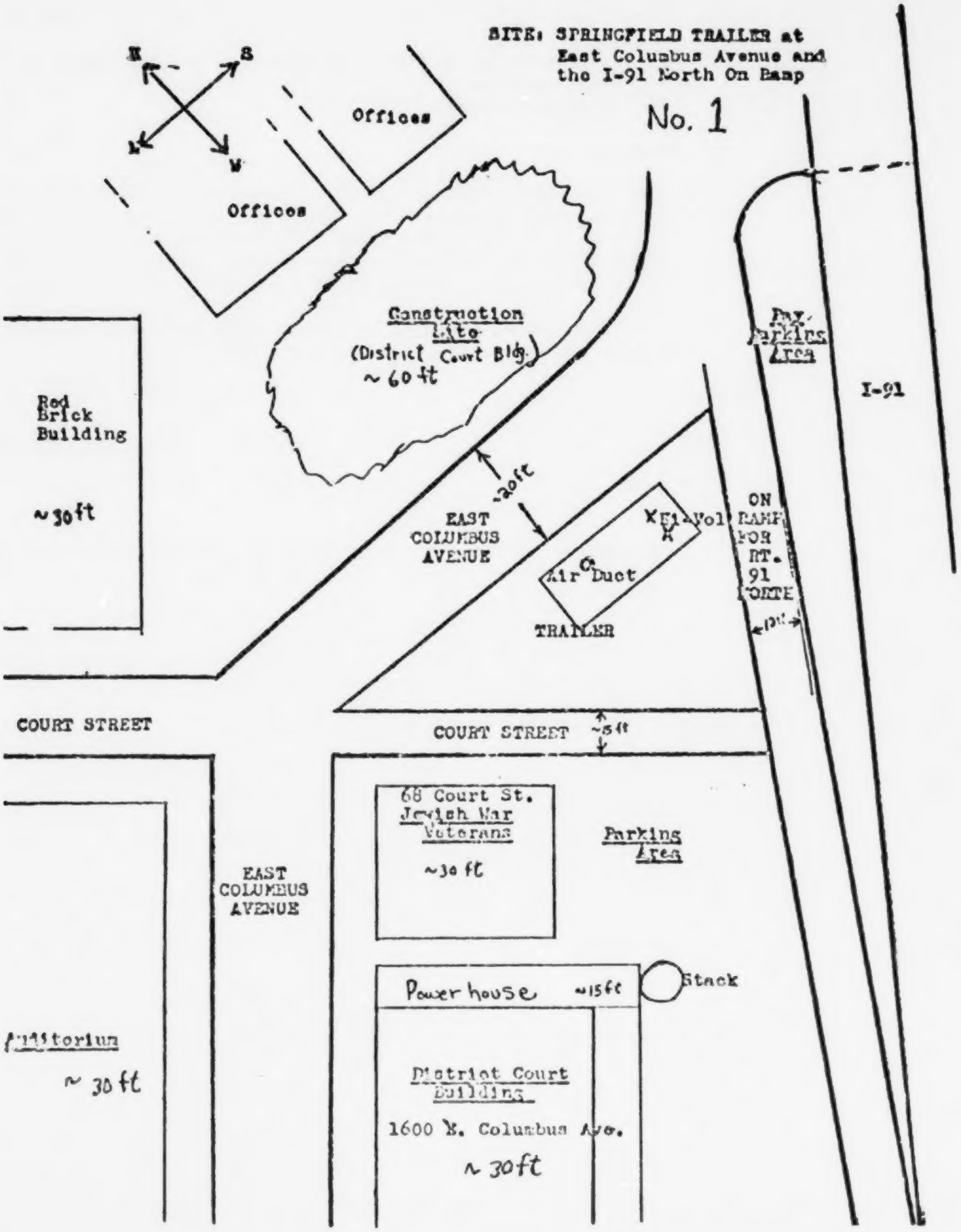
A bendix ozone monitor may be set up in Agawam. This proposal is still very tentative.

Very truly yours,

Alan Graichen

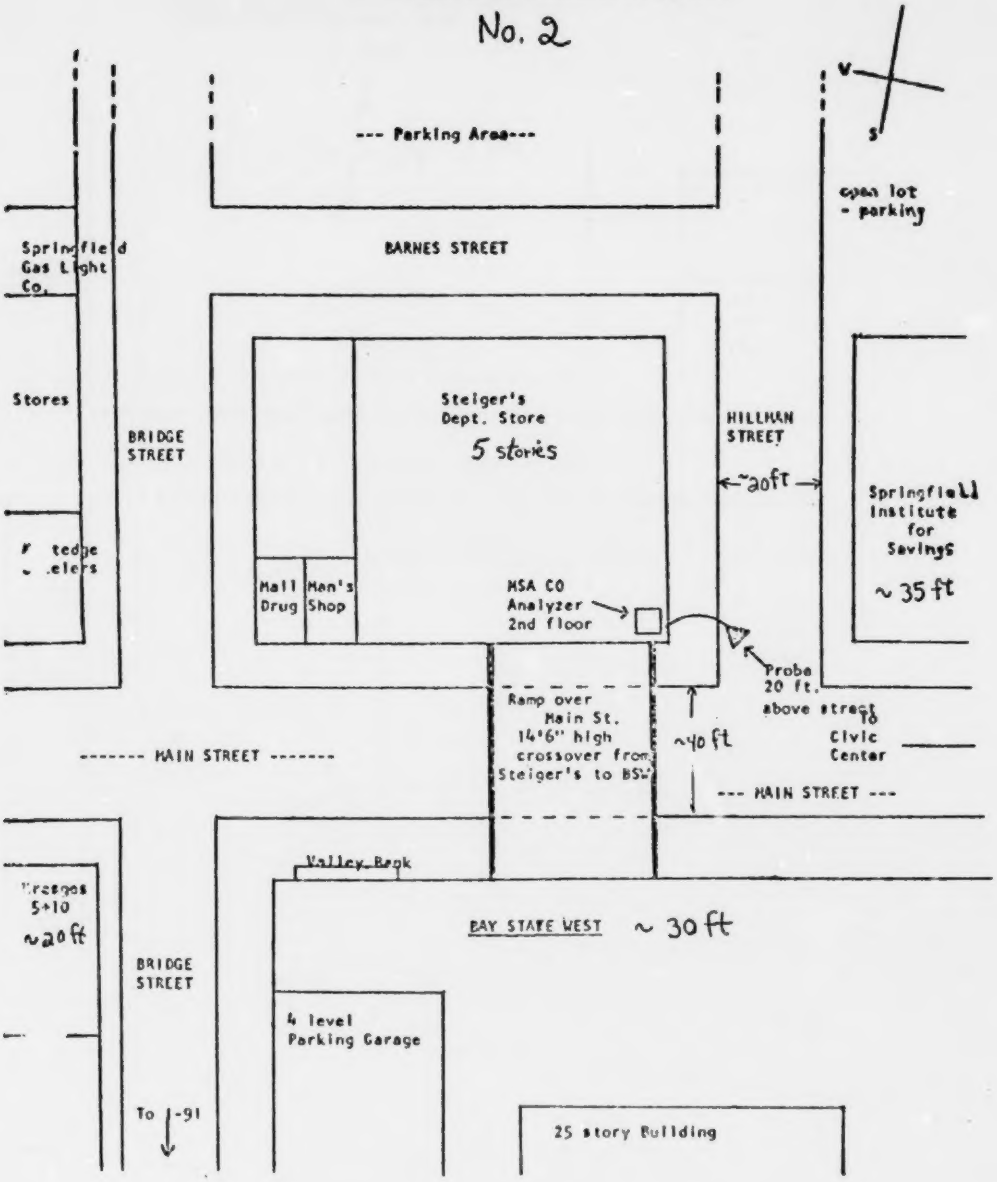
Alan Graichen
Senior Engineer

AG/jp


SITE: SPRINGFIELD TRAILER at
East Columbus Avenue and
the I-91 North On Ramp
No. 1
N
S
E
W
Offices
Offices
Construction Site
(District Court Bldg.)
~60 ft
Red Brick Building
~30 ft
~20 ft
EAST COLUMBUS AVENUE
X Hi-Vol
X
Air Duct
TRAILER
ON RAMP FOR RT. 91 NORTH
10'
Pay Parking Area
I-91
COURT STREET
COURT STREET
~5 ft
68 Court St.
Jewish War Veterans
~30 ft
Parking Area
EAST COLUMBUS AVENUE
Power house
~15 ft
Stack
Auditorium
~30 ft
District Court Building
1600 E. Columbus Ave.
~30 ft

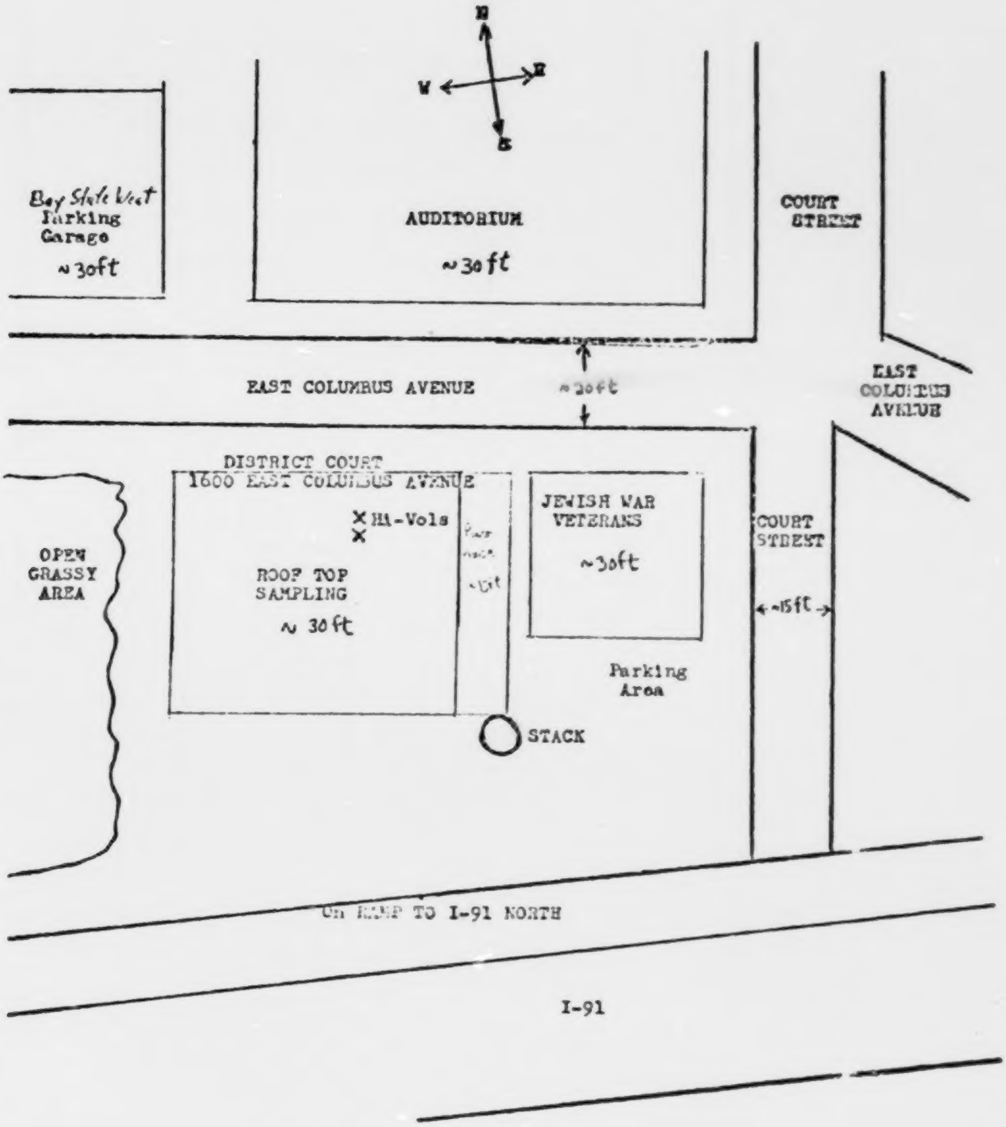
Site: Steiger's Department Store - second floor
Main Street, Downtown Springfield

No. 2


N
S
--- Parking Area---
open lot
- parking
BARNES STREET
Springfield
Gas Light
Co.
Stores
BRIDGE
STREET
Steiger's
Dept. Store
5 stories
HILLMAN
STREET
~20ft
Springfield
Institute
for
Savings
~35 ft
tedge
elers
Mall
Drug
Men's
Shop
MSA CO
Analyzer
2nd floor
Probe
20 ft.
above street
Ramp over
Main St.
14'6" high
crossover from
Steiger's to BSW
~40 ft
To
Civic
Center
------- MAIN STREET -------
--- MAIN STREET ---
Valley Bank
Kresges
5+10
~20 ft
BAY STATE WEST
~30 ft
BRIDGE
STREET
4 level
Parking Garage
To I-91
25 story Building

SITE: SPRINGFIELD DISTRICT COURT
1600 East Columbus Avenue

No. 3


N
W
E
S
Bay State West
Parking
Garage
~30ft
AUDITORIUM
~30 ft
COURT
STREET
EAST COLUMBUS AVENUE
~30ft
EAST
COLUMBUS
AVENUE
DISTRICT COURT
1600 EAST COLUMBUS AVENUE
× Hi-Vols
×
OPEN
GRASSY
AREA
ROOF TOP
SAMPLING
~ 30 ft
~15ft
JEWISH WAR
VETERANS
~30ft
COURT
STREET
~15ft
Parking
Area
STACK
On RAMP TO I-91 NORTH
I-91

APPENDIX C

DESCRIPTION OF THE APRAC-1a MODEL

As discussed in Section III, the effect of different transportation control strategies upon CO levels throughout the Springfield CBD was evaluated for worst day conditions by means of the APRAC-1a computer model. While only a brief outline of the calculation technique will be furnished here, a detailed description of the model may be found elsewhere.[1,2,3,4] The purpose of the model is the prediction of hourly CO concentrations at specific receptor locations based upon traffic link emissions and meteorological data.

The concentration contribution at a particular receptor location from links other than the receptor street is calculated by means of a receptor oriented Gaussian plume model.[5] For a given hour the model sets up a series of area sources upwind of the receptor point. Each of these area sources is assigned an emission strength based upon the link elements contained within each. The vertical dispersion of the CO plume which occurs between the area source and receptor will depend upon a vertical dispersion parameter which is in turn a function of wind speed, cloud cover, and time of day. The dilution factor of CO along the axis of the plume is proportional to the wind speed.

The Gaussian plume concentrations are then added to values obtained by use of a "street canyon" submodel which accounts in a more realistic way for the effect of emissions on the receptor street itself. An illustration of the physical basis for this submodel is given in Figure 1.[4] Winds blowing over the canyon carry background "roof top" concentrations

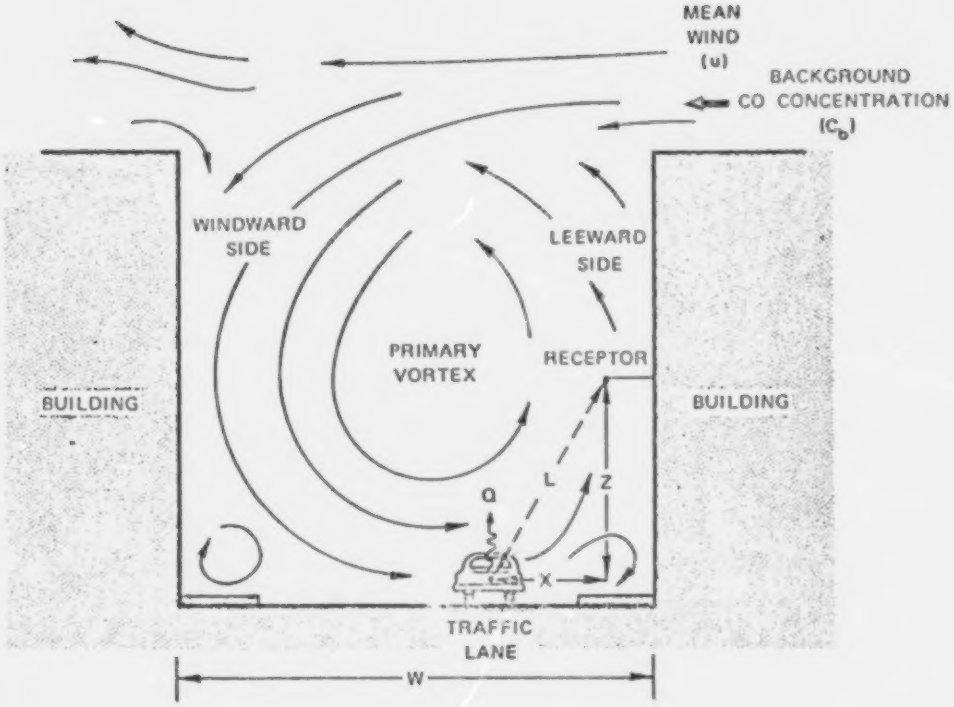

MEAN
WIND
(u)
BACKGROUND
CO CONCENTRATION
(C_b)
WINDWARD
SIDE
LEEWARD
SIDE
PRIMARY
VORTEX
RECEPTOR
BUILDING
BUILDING
Q
L
Z
X
TRAFFIC
LANE
W

Figure C-1. Cross-street circulation between buildings of CO down the wall of buildings on the opposite side of the street. Emissions from traffic on the street are then picked up by the eddy and transported to the upwind side of the street and then up the side of the buildings. A circulation pattern of this type would result in the highest concentations being observed at street level on the upwind side. In the context of the model the only physical street canyon variables which are at the disposal of the user are the width of the street (building to building) and its heading with respect to north. The building height is fixed at 38.8 meters. If the street canyon option is utilized, four CO levels are given for a particular receptor, two near street level on opposite sides of the link, and two more concentrations at a higher elevation. For comparison with data the highest of the four values was chosen.

Some further insight into the operation of the model can be gained from the following discussion of input data requirements and the relative importance of the associated variables.

1. Emissions Data - In the APRAC program emissions are parameterized simply in the form of an emission factor power law.

   $$E = \alpha S^{-\beta}$$

   where E = emission factor (gm/mi)

   α, β = constants for a particular year, model year distribution, and weighted annual travel distribution

   S = average traffic speed (mi/hr)

   The constants α, β may be obtained indirectly from the FMVECP emission factors.[6] The speed S is available in the emission factor calculation since each link in the data set is characterized by one of eight speed classes.

2. Meteorological Data

   a. Surface observations - Hourly measurements of wind speed, wind direction, temperature, and cloud cover are utilized in the calculation of CO transport and dispersion. Wind speed, cloud cover and time of day are used in the calculation of the vertical dispersion coefficient used in the gaussian plume submodel. The street canyon submodel requires only wind speed and direction since the dilution volume will depend upon the building configuration at any given receptor location.

b. Atmospheric soundings - Temperature variation with height is used along with maximum and minimum daily surface temperatures to determine an hourly mixing depth, which sets an upper limit to the vertical migration of the pollutant. This mixing height parameter is usually only important in the calculation of CO concentrations due to emissions from distant sources and obviously plays no role in the street canyon calculation.

Both surface observations and atmospheric soundings may be obtained from the National Climatic Center, Asheville, North Carolina, for weather stations closest to the location of interest.

3. Traffic Volume Data - The basic traffic input for the APRAC model is the number of vehicles per day for an array of links whose endpoint coordinates are specified on a rectangular system in units of 0.01 miles. To account for the curvature of a particular link, the actual length of the roadway between the endpoints is input. As mentioned before, each link is also assigned an appropriate speed classification. Nonlink traffic volumes may be assigned to 4 mi^2 grid squares superimposed upon the traffic network.

The daily traffic flow volume is apportioned for each hour of the day according to hourly traffic flow distributions specific to weekdays, Saturdays, and Sundays. There is also the option in the program of selecting a given hour of the day as a peak hour, thereby reducing the average speed on all links by 15 percent. This option was not, however, utilized in the case of Springfield, because the speed data collected during the traffic study did not indicate the need for such an across-the-board adjustment.

REFERENCES

1. Ludwig, F. L., W. B. Johnson, A. E. Moon, and R. L. Mancuso. A Practical Multipurpose Diffusion Model for Carbon Monoxide. Final Report, Contracts CAPA-3-68 and CPA 22-69-64, Stanford Research Institute, Menlo Park, Calif. 184 pp, (NTIS-PB 196 003). 1970

2. Johnson, W. B., W. F. Dabberdt, F. L. Ludwig, and R. J. Allen. Field Study for Initial Evaluation of an Urban Diffusion Model for Carbon Monoxide. Comprehensive Report, Contract CAPA-3-68 (1-69), Stanford Research Institute, Menlo Park, Calif. 240 pp, (NTIS-PB 203 469). 1971

3. Ludwig, F. L. and W. F. Dabberdt. Evaluation of the APRAC-1A Urban Diffusion Model for Carbon Monoxide. Final Report, Contract CAPA-3-68 (1-69), Stanford Research Institute, Menlo Park, Calif. 167 pp, (NTIS-PB 210 819). 1972

4. Mancuso, R. L. and F. L. Ludwig. User's Manual for the APRAC-1A Urban Diffusion Model Computer Program. Contract CAPA-3-68 (1-69), Stanford Research Institute, Menlo Park, Calif. 119 pp, (NTIS-PB 213 091). 1972

5. Gifford, F. A., Jr. An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere. Ch. 3. Meteorology and Atomic Energy 1968. (D. Slade, ed.) USAEC-TID-24190. 1968

6. Kircher, D. S. and C. C. Masser. Supplement No. 5, Attachment No. 1 for Compilation of Air Pollution Emission Factors AP-42. Second Edition.

APPENDIX D

STABILITY ROSES

The following pages reproduce stability data from Westover Air Force Base, Chicopee Falls, Massachusetts. The source is Reference 19 of Section III of this report.

Grid values represent wind direction distribution in percent.
Velocity distribution by direction included (see legend).

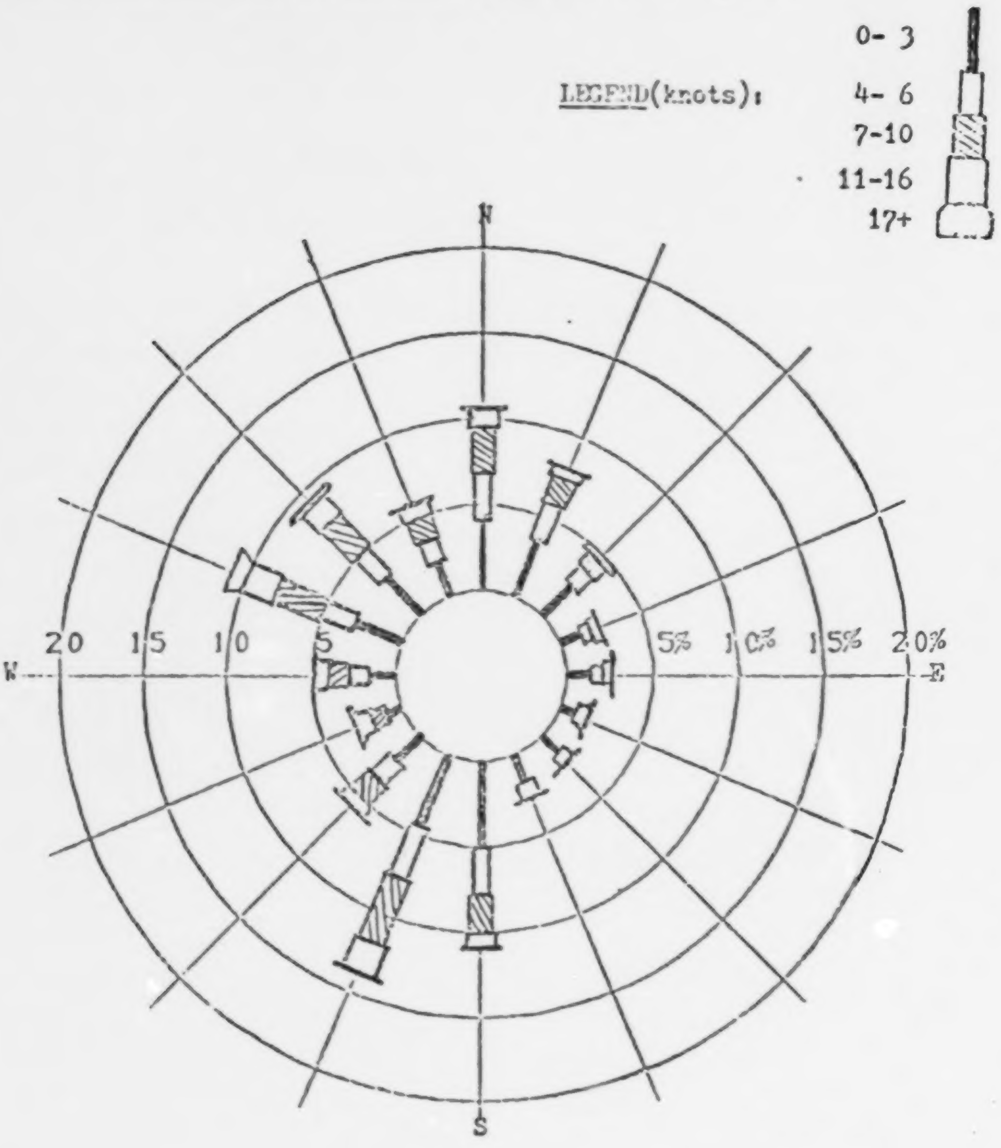


Figure D-1. Five year annual stability wind rose for all stability classes covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

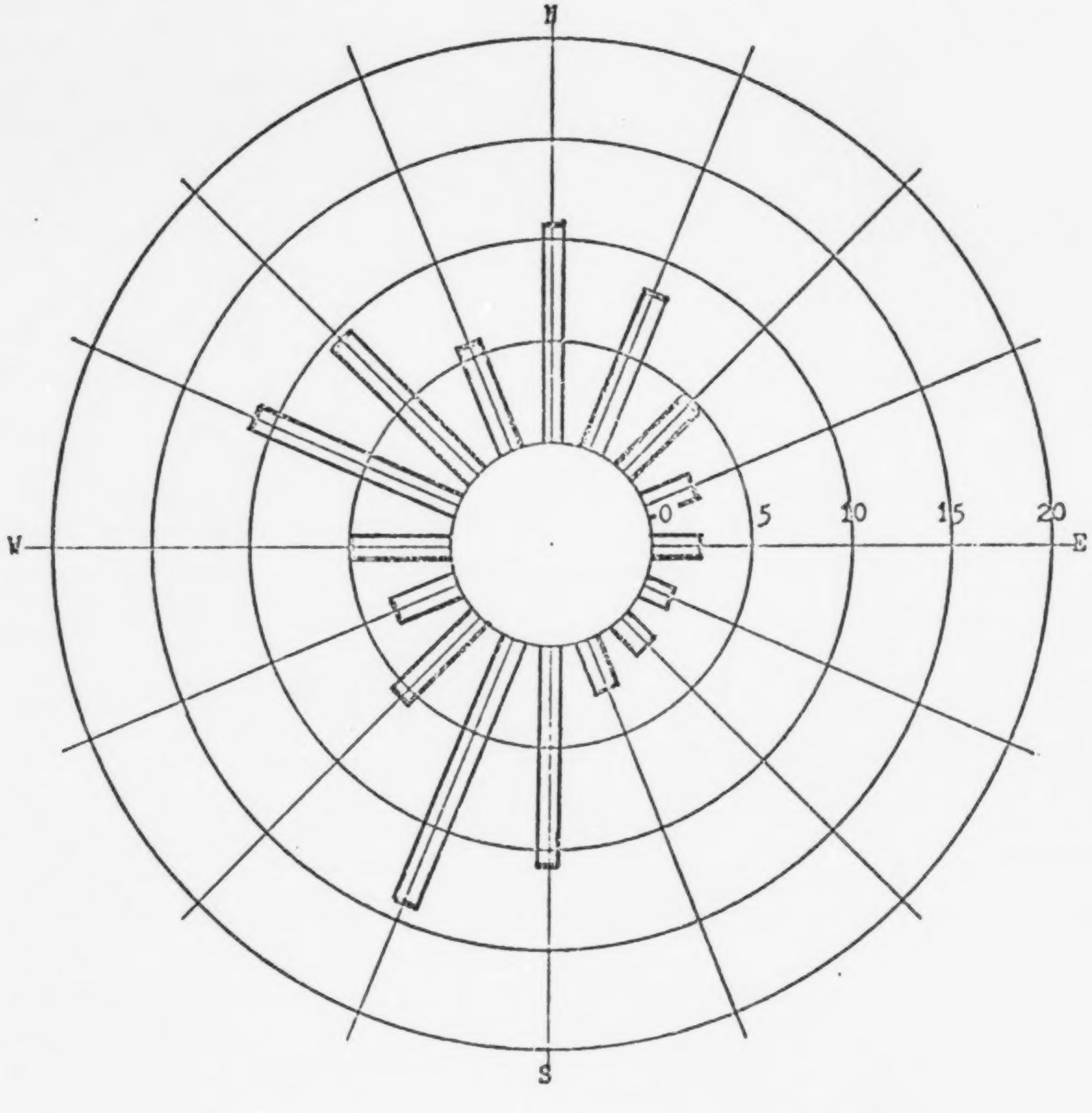


Figure D-2. Five year annual stability wind rose for all stability classes covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

Number at end of a frequency shaft represents average wind speed (knots) for that direction for the given stability class.

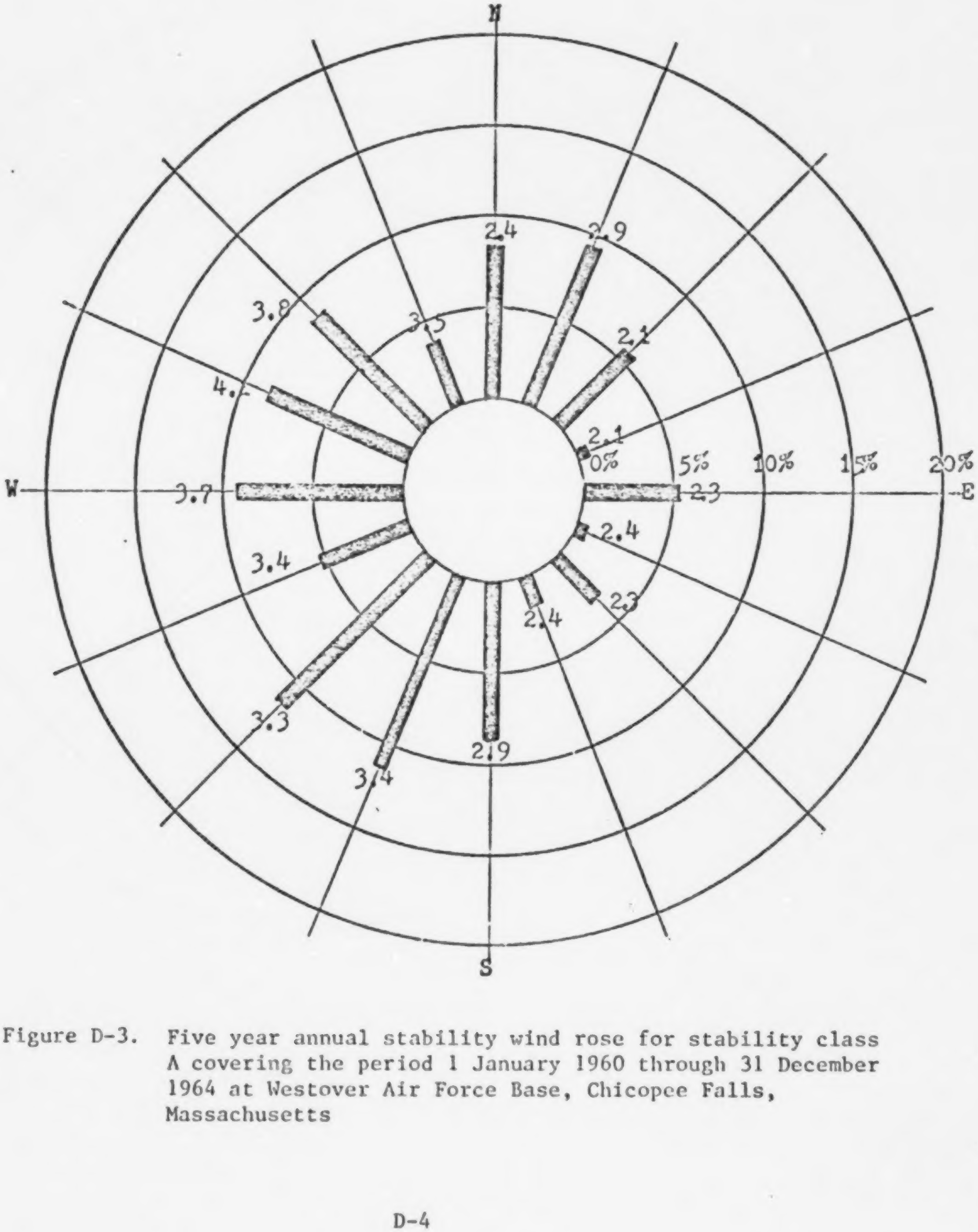


Figure D-3. Five year annual stability wind rose for stability class A covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

Number at end of a frequency shaft represents average wind speed (knots) for that direction for the given stability class.

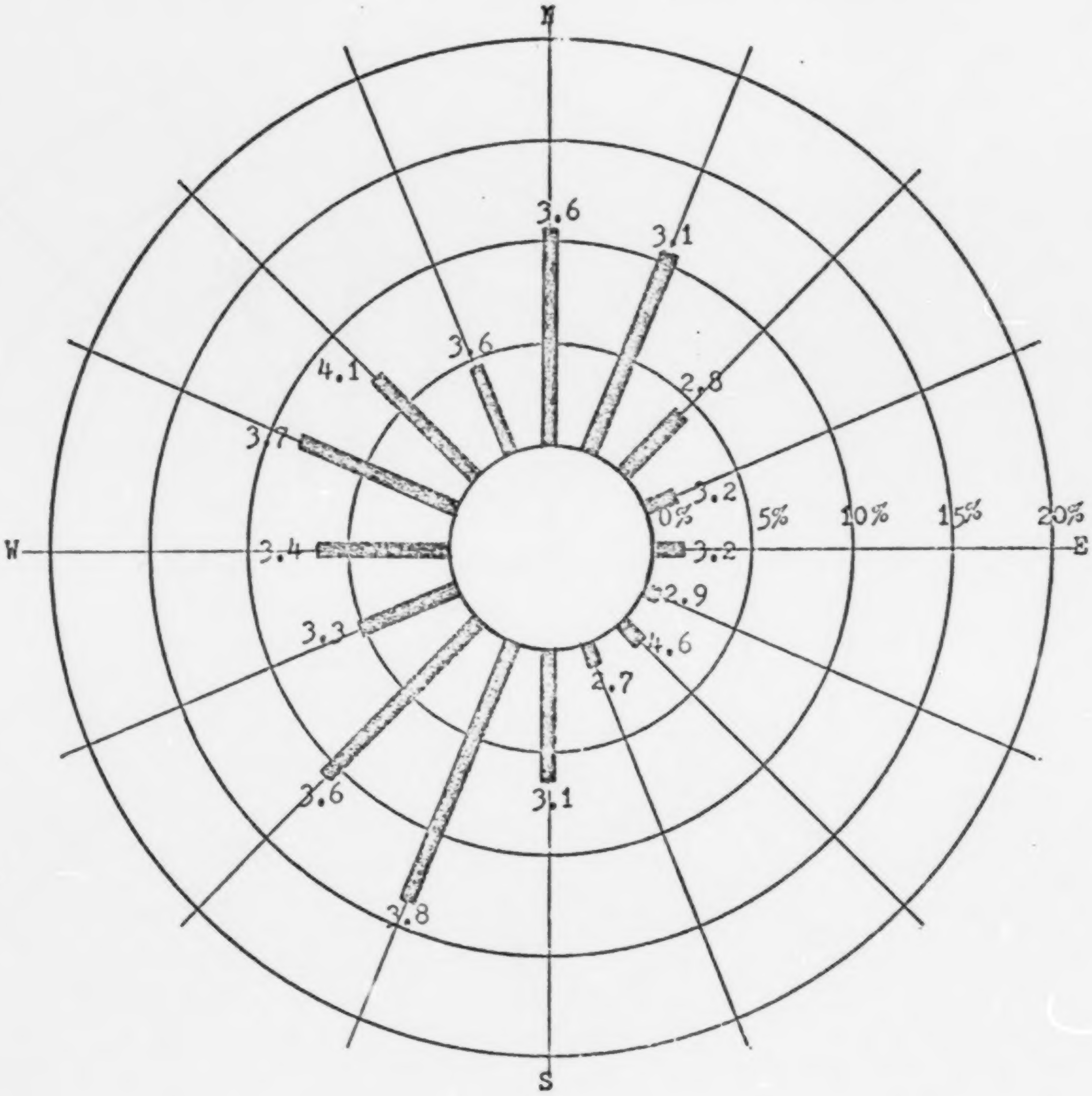


Figure D-4. Five year annual stability wind rose for stability class B covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

Number at end of a frequency shaft represents average wind speed (knots) for that direction for the given stability class.

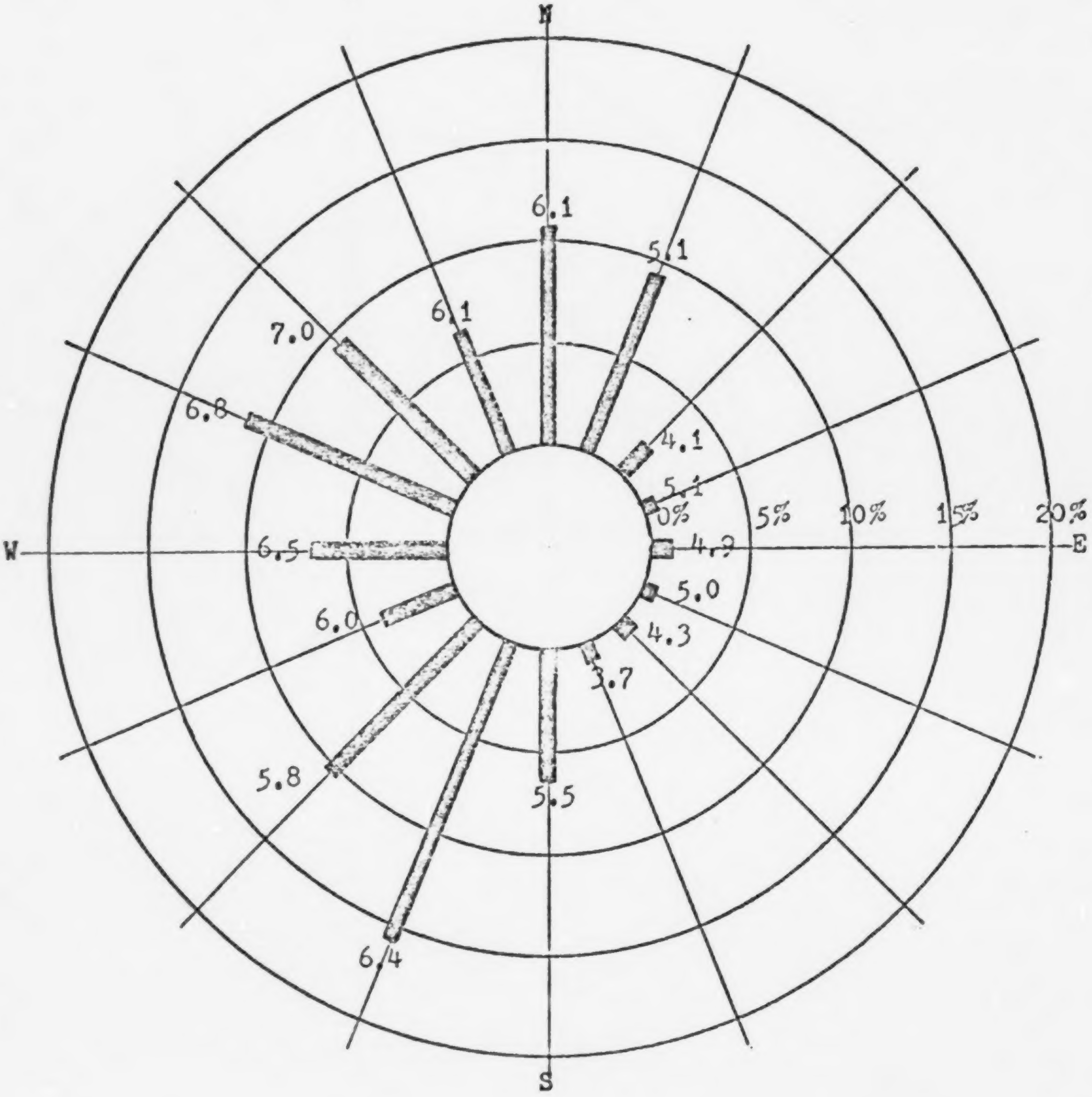


Figure D-5. Five year annual stability wind rose for stability class C covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

Number at end of a frequency shaft represents average wind speed (knots) for that direction for the given stability class.

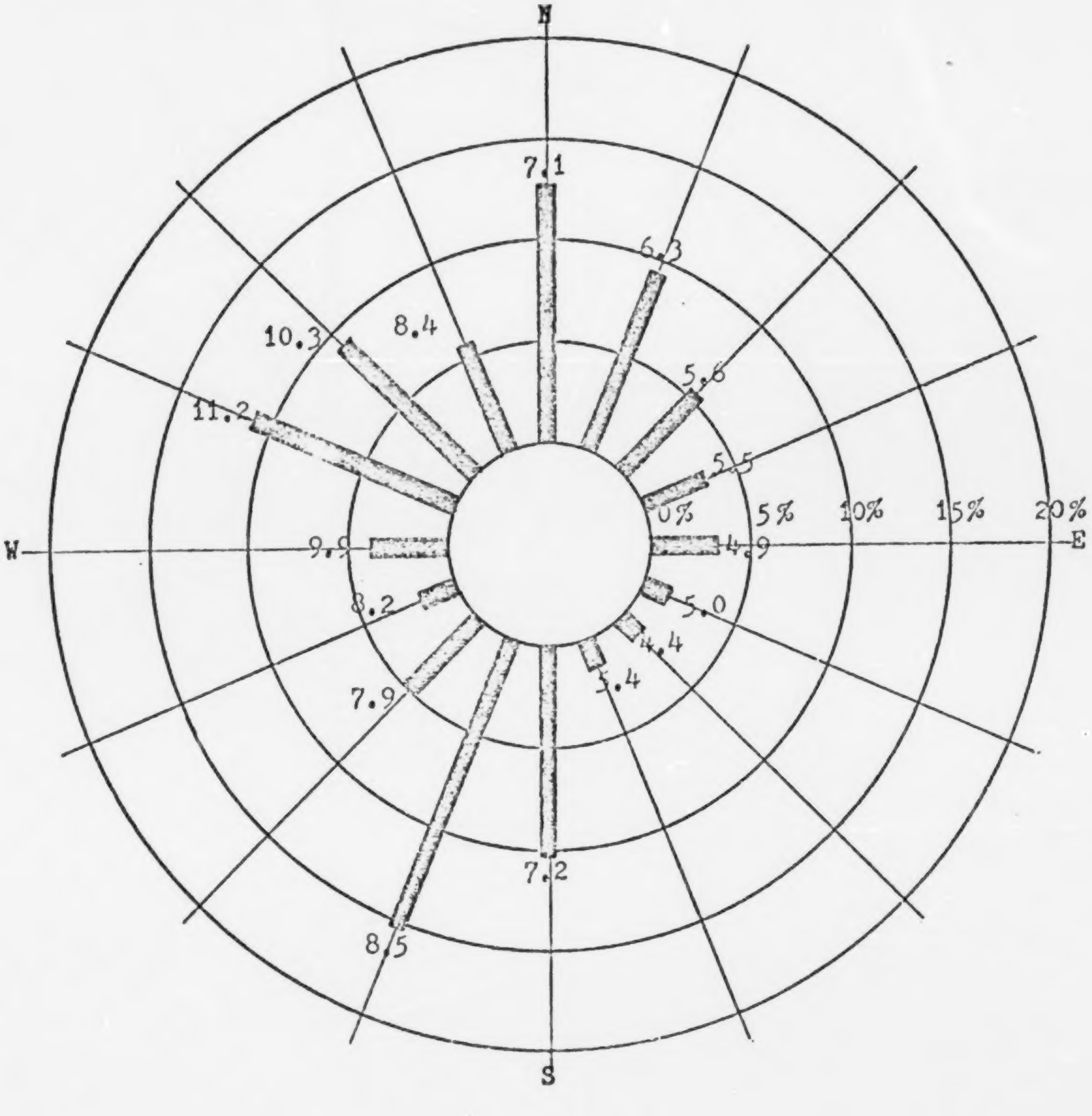


Figure D-6. Five year annual stability wind rose for stability class D covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

Grid values represent wind direction distribution in percent.

Number at end of a frequency shaft represents average wind speed (knots) for that direction for the given stability class.

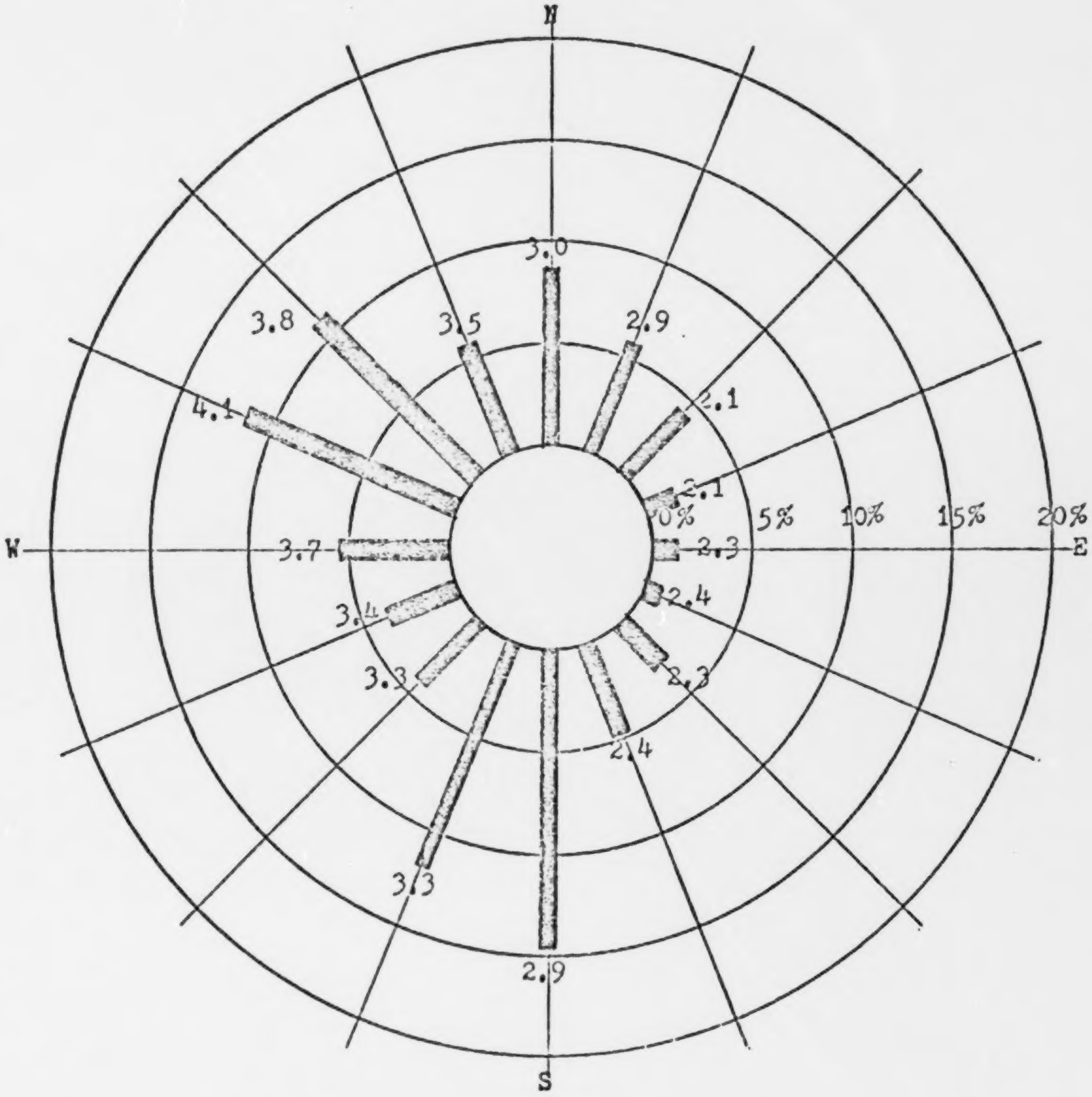


Figure D-7. Five year annual stability wind rose for stability class E covering the period 1 January 1960 through 31 December 1964 at Westover Air Force Base, Chicopee Falls, Massachusetts

APPENDIX E

SPRINGFIELD TRAFFIC STUDY

Following this page is the Scope of Work for a traffic study in downtown Springfield accomplished by GCA/Technology Division as part of the development of this transportation Control Plan.

SCOPE OF WORK

A. General:

The contractor under Task Order No. 10, Contract No. 68-02-1376 has been identifying and developing transportation control plans for the Springfield, Massachusetts area. During the process of his investigations he has determined that an adequate data base for the estimation of the travel reductions resulting from his formulation of alternate transportation control plans is not available. Accordingly it is necessary for the contractor to collect the data enumerated below.

B. Specific Tasks:

The contractor shall complete the following specific Tasks and integate the data into the Final Contract documentation.

Item I - Parking Analysis:

The contractor shall determine the actual number of vehicle trips that would be affected by implementing a parking restriction plan - this, essentially, will be the typical daily demand for all-day parking within the area.

Since the Springfield Planning Department has studied parking in the downtown area, much of the effort envisioned will be geared toward updating and verifying data established in their study. Information to be updated includes the overall inventory of facilities (both curb and off-street spaces). This data should be available from either the Planning Department or the Traffic Engineering Department.

The Planning Department's study also investigated parking utilization within the downtown area. This information will be verified and supplemented by field studies and interviews of facility operators. The data obtained will indicate the time-demand for parking, or more specifically, the demand for all-day commuter parking.

Item II - Travel-Time Analysis:

The contractor shall collect travel-time data to determine the potential for increasing the efficiency of traffic flow on the street network. These data will also be used for predicting changes in traffic patterns that may occur upon implementation of a particular strategy, as well as for developing a basic street classification system in connection with estimating the scope of transportation controls required.

Item III - Physical Inventory:

The contractor will collect data defining the physical layout of the street network as inputs in determining traffic flow improvement potential. The locations where data are required can be limited to the more important intersections, mainly:

East Columbus Avenue/State Street
East Columbus Avenue/Pynchon Street
East Columbus Avenue/Vernon Street
Main Street/Worthington Street
Main Street/Court Street
Main Street/State Street
Dwight Street/State Street
Dwight Street/Lyman Street
Chestnut Street/Bridge Street
Chestnut Street/State Street/Maple Street
Memorial Bridge Rotary

The data required for each of the locations consists of approach widths, location of curb parking and bus stops within the intersection, and pavement delineation (number and type of lanes used).

Item IV - Traffic Volume Data:

The contractor will collect traffic volume data through the employment of a combination of automatic traffic recorder (ATR) counts of at least 24-hour duration, and manual short-term counts. These data are required for all arterials and important local streets within the downtown area in order to determine current travel (vehicle-miles of travel). This data will supplement data available from the Springfield Traffic Engineering Department.

Item V - Origin-Destination Study:

The contractor will determine various characteristics of trips through the downtown area including:

1) Trip origin and destination.
2) Trip purpose.
3) Trip frequency.
4) Route traveled through the downtown area.

Item VI - Transit Data:

The contractor shall determine the existing usage of intercity transit as well as the potential for increased transit service. The data to be collected shall include ridership, capacities, and routing for service in or through the study area, as well as data on the future plans for changing service or developing new service. Much of this data should be available from the transit operator and through the consultant (Wilbur Smith and Associates) currently developing a regional transit plan for the area.

APPENDIX F

LINK DATA FOR DOWNTOWN SPRINGFIELD

The following present a summary of the link data used to estimate carbon monoxide concentrations and assess the effects of proposed strategies in downtown Springfield. Shown are data representing speeds and volumes for three conditions:

- The existing circulation system assuming 1973 traffic characteristics.
- The proposed circulation system assuming 1973 traffic characteristics.
- The proposed circulation system plus all other proposed strategies assuming 1973 traffic characteristics.

Table F-1. SPRINGFIELD LINK DATA

Link description				1973 speed and volume characteristics					
				No strategy		Circulation system changes only		All strategies applied	
Link no.	Street	Limits	Link length (miles)	Volume	Speed code[a]	Volume	Speed code[a]	Volume	Speed code[a]
1	W. Union	W. Columbus-E. Columbus	0.06	1,000	2	5,000	2	5,000	2
2	Union	E. Columbus-Main	0.18	5,400	• 2	4,000	2	4,000	2
3	Union	Main-Maple	0.21	2,000	2	2,000	2	2,000	2
4	Union	Maple-School	0.13	750	3	750	3	750	3
5	Park	Entire street	0.21	500	3	500	3	500	3
6	Howard	Entire street	0.18	200	2	250	2	250	2
7	High	Entire street	0.16	250	2	250	2	250	2
8	Bliss	Entire street	0.19	4,000	2	4,000	2	4,000	2
9	Temple	Entire street	0.19	250	2	250	2	250	2
10	State	E. Columbus-W. Columbus	0.06	8,000	2	18,000	2	16,000	2
11	State	E. Columbus-Main	0.18	12,000	2	12.000	2	12,000	2
12	State	Main-Dwight	0.10	16,000	1	18,000	2	16,000	2
13	State	Dwight-Chestnut	0.05	16,000	3	16,000	3	15,500	2
14	State	Chestnut-School	0.22	20,000	4	20,000	4	19,000	2
15	Court Sq. Ave.	Court-Elm	0.05	1,000	2	1,000	2	1,000	2
16	Elm	Court Sq. Ave.-Main	0.06	1,000	2	1,000	2	1,000	2
17	Pynchon	Entire street	0.14	1,800	2	700	2	700	2
18	Edwards	Entire street	0.14	250	3	250	3	250	3
19	Vernon	Entire street	0.13	10,000	3	14,000	3	12,000	3
20	Court	Entire street	0.15	6,500	3	5,000	3	5,000	3
21	E. Court	Entire street	0.10	5,500	3	2,000	3	2,000	3
22	Harrison	Main-Dwight	0.13	6,000	3	12,000	3	11,000	3
23	Harrison	Dwight-Chestnut	0.05	2,000	2	4,000	2	3,000	2
24	Matoon & Salem	Entire street	0.20	100	2	100	2	100	2
25	Hillman	Main-Dwight	0.14	3,000	1	300	2	300	2
26	Hillman	Dwight-Chestnut	0.06	1,000	2	2,000	2	2,000	2
27	Pearl	One-way eastbound	0.05	2,500	2	3,000	3	3,000	3
28	Pearl	One-way westbound	0.05	4,500	2	4,000	2	4,000	2
29	Pearl	One-way sections-School	0.15	9,000	3	7,000	3	7,000	3
30	Bridge	E. Columbus-Main	0.10	5,000	2	10	3	10	3
31	Bridge	Main-Dwight	0.16	8,000	3	500	3	500	3
32	Bridge	Dwight-Chestnut	0.07	5,000	2	4,000	2	4,000	2
33	Winter	Entire street	0.18	200	2	200	2	200	2
34	Worthington	E. Columbus-Main	0.09	5,300	2	2,000	3	2,000	3
35	Worthington	Main-Dwight	0.18	10,000	2	3,000	3	4,000	3
36	Worthington	Dwight-Chestnut	0.08	9,500	3	4,000	3	5,000	3
37	Worthington	Chestnut-Spring	0.17	10,100	3	7,000	3	7,000	3
38	Fort	Entire street	0.09	1,000	2	10	3	10	3
39	Taylor	Main-Dwight	0.19	1,500	2	10	3	10	3
40	Taylor	Dwight-Chestnut	0.09	2,000	2	3,000	3	3,000	3
41	Taylor	Chestnut-Spring	0.15	4,000	3	3,000	3	3,000	3
42	Hampden	Entire street	0.12	4,000	2	2,000	3	2,000	3
43	Lyman	Main-Dwight	0.19	1,500	2	2,000	3	2,000	3
44	Lyman	Dwight-Chestnut	0.10	1,200	3	2,000	2	2,000	2
45	Lyman	Chestnut-Spring	0.14	500	2	1,000	3	1,000	3
46	Gridiron	Entire street	0.11	500	3	10	3	10	3
47	Murray eastbound	Entire street	0.32	1,000	2	1,000	2	1,000	2
48	Liberty	W. Columbus-Main	0.14	3,000	2	8,000	3	10,000	3
49	Liberty	Main-Dwight	0.21	6,000	2	8,000	3	9,000	3
50	Liberty	Dwight-Chestnut	0.12	7,000	3	8,000	3	8,000	3
51	Liberty	Chestnut-eastbound	0.18	9,300	3	9,300	3	9,300	3
52	Congress	Main-Dwight	0.21	4,000	2	4,000	2	6,000	3
53	Congress	Dwight-Chestnut	0.11	3,000	2	3,000	2	5,000	3
54	Emery	Entire street	0.13	2,500	2	2,500	2	4,000	3
55	Spring	Lyman-Worthington	0.10	1,000	3	1,000	3	1,000	3
56	Spring	Worthington-State	0.35	2,700	3	2,700	3	2,700	3
57	Eliot	Salem-State	0.20	250	3	250	3	250	3
58	Chestnut	I-291-Liberty	0.23	14,500	3	14,500	3	13,000	3
59	Chestnut	Liberty-Lyman	0.14	7,500	3	10,000	3	10,000	3
60	Chestnut	Lyman-Taylor	0.06	7,000	3	10,000	3	10,000	3
61	Chestnut	Taylor-Worthington	0.05	7,000	2	11,000	3	11,000	3
62	Chestnut	Worthington-Bridge	0.06	6,500	3	8,000	3	8,000	3
63	Chestnut	Bridge-Harrison	0.11	6,500	2	7,000	2	7,000	2
64	Chestnut	Harrison-State	0.18	6,000	4	8,000	3	8,000	3
65	Maple	State-Dwight	0.12	12,100	2	10,000	3	10,000	3
66	Maple	Dwight-Union	0.09	15,000	3	15,000	3	13,000	3
67	Maple	Union-Central	0.20	12,000	3	12,000	3	11,000	3

[a] See Table F-2.

Table F-1 (Continued). SPRINGFIELD LINK DATA

Link description				1973 speed and volume characteristics					
				No strategy		Circulation system changes only		All strategies applied	
Link no.	Street	Limits	Link length (miles)	Volume	Speed code[a]	Volume	Speed code[a]	Volume	Speed code[a]
68	Dwight	I-291-Liberty	0.21	4,000	3	4,000	3	6,000	3
69	Dwight	Liberty-Lyman	0.12	11,500	2	14,000	3	13,000	3
70	Dwight	Lyman-Worthington	0.10	11,000	3	17,000	3	15,000	3
71	Dwight	Worthington-Hillman	0.10	13,200	3	17,000	3	15,000	3
72	Dwight	Hillman-Harrison	0.07	10,000	3	15,000	2	16,000	2
73	Dwight	Harrison-Court	0.08	10,000	3	12,000	3	11,000	3
74	Dwight	Court-State	0.10	8,000	2	10,000	3	10,000	3
75	Dwight	State-Maple	0.15	4,000	4	5,000	4	5,000	4
76	Willow	Entire street	0.19	100	2	100	2	100	2
77	Main	I-291-Liberty	0.26	11,000	3	11,000	3	11,000	3
78	Main	Liberty-Lyman	0.13	8,000	2	4,000	3	5,000	3
79	Main	Lyman-Worthington	0.10	10,000	3	5,000	3	5,000	3
80	Main	Worthington-Bridge	0.06	15,500	1	6,000	3	5,000	3
81	Main	Bridge-Vernon	0.09	16,500	1	6,000	3	6,000	3
82	Main	Vernon-Court	0.12	15,000	1	5,000	2	5,000	2
83	Main	Court-State	0.10	13,500	2	9,000	3	8,000	3
84	Main	State-Union	0.19	11,000	2	10,000	3	9,000	3
85	Main	Union-Norwood	0.42	15,500	3	15,500	3	15,500	3
86	E. Columbus	I-291-Emery	0.18	2,000	5	3,000	5	3,000	5
87	E. Columbus	Emery-Liberty	0.12	2,500	4	4,000	4	5,000	3
88	E. Columbus	Liberty-Gridiron	0.10	3,000	3	9,000	3	9,000	3
89	E. Columbus	Gridiron-Worthington	0.18	3,500	3	15,000	3	14,000	3
90	E. Columbus	Worthington-Bridge	0.06	8,500	3	22,000	3	20,000	3
91	E. Columbus	Bridge-Traffic loop	0.05	15,000	3	22,000	3	20,000	3
92	E. Columbus	Traffic loop-Vernon	0.04	20,000	3	22,000	3	20,000	3
93	E. Columbus	Vernon-Traffic loop	0.03	23,000	3	24,000	2	21,000	2
94	E. Columbus	Traffic loop-Court	0.08	16,000	3	23,000	3	21,000	3
95	E. Columbus	Court-I-91 ramp	0.05	12,000	3	18,000	3	18,000	3
96	E. Columbus	I-91 ramp-State	0.06	14,000	3	23,000	3	23,000	3
97	E. Columbus	State-Union	0.18	10,000	3	12,000	3	10,000	3
98	E. Columbus	Union-Norwood	0.36	8,000	4	7,000	4	7,000	4
99	W. Columbus	I-291-Emery	0.19	2,500	5	2,500	5	4,000	5
100	W. Columbus	Emery-Liberty	0.12	4,000	4	4,000	4	4,000	4
101	W. Columbus	Liberty-Two-way	0.07	4,500	4	8,000	4	8,000	4
102	W. Columbus	Two-way-Gridiron	0.05	4,500	4	8,000	4	8,000	4
103	W. Columbus	Gridiron-Hampden	0.06	4,500	4	8,000	3	8,000	3
104	W. Columbus	Hampden-I-91 ramp	0.11	8,000	4	18,000	3	16,000	3
105	W. Columbus	I-91 ramp-Traffic loop	0.06	18,000	4	27,000	3	24,000	3
106	W. Columbus	Traffic loop-Memorial bridge	0.05	26,000	4	27,000	3	24,000	3
107	W. Columbus	Memorial bridge-Traffic loop	0.04	26,000	3	29,000	3	26,000	3
108	W. Columbus	Traffic loop-State	0.18	15,000	3	29,000	3	26,000	3
109	W. Columbus	State-I-91 ramp	0.04	14,500	3	11,000	3	11,000	3
110	W. Columbus	I-91 ramp-Union	0.14	11,000	3	6,000	3	6,000	3
111	W. Columbus	Union-I-91 ramp	0.36	9,000	5	9,000	5	9,000	5
112	Route 5	North of Memorial Bridge	0.66	24,000	5	28,000	5	24,000	5
113	Route 5	South of Memorial Bridge	0.64	26,500	5	26,500	5	26,500	5
114	Wilcox	Entire street	0.18	200	2	200	2	200	2
115	William	Entire street	0.18	200	2	200	2	200	2
116	Freemont	Entire street	0.16	200	2	200	2	200	2
117	Central	Main-Maple	0.25	3,500	3	3,500	3	3,500	3
118	Central	Beyond Maple	0.17	7,000	3	7,000	3	7,000	3
119	I-291	East on Chestnut St.	0.30	51,000	5	51,000	5	51,000	5
120	I-291	Chestnut-Ramps	0.37	25,000	5	25,000	5	25,000	5
121	I-291	Northerly ramps to-from I-91	0.09	10,000	5	10,000	5	10,000	5
122	I-291	Southerly ramps to-from I-91	0.10	15,000	5	15,000	5	15,000	5
123	I-91	North on I-291 northerly ramps	0.10	60,000	5	60,000	5	60,000	5
124	I-91	Between I-291 ramps	0.08	55,000	5	55,000	5	55,000	5
125	I-91	I-291 South Ramp-E. Columbus	0.30	80,000	5	80,000	5	80,000	5
126	I-91	Between Columbus Ave. Ramps	0.61	50,000	5	50,000	5	50,000	5
127	I-91	Columbus Ave. Ramps-End Area	0.40	60,000	5	60,000	5	60,000	5
128	Ramp 1	I-91	0.17	10,000	3	10,000	3	10,000	3
129	Ramp 2	I-91	0.17	10,000	4	5,000	4	5,000	4
130	Ramp 3	I-91	0.14	8,000	4	5,000	4	5,000	4
131	Ramp 4	I-91	0.09	10,000	3	10,000	3	10,000	3
132	Ramp 5	I-91	0.12	5,000	3	5,000	3	5,000	3
133	Ramp 6	I-91	0.08	4,000	4	7,000	4	7,000	4
134	Memorial Bridge	Route 5-W. Columbus	0.30	28,000	2	32,000	3	32,000	3

[a] See Table F-2.

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Table F-2. LINK DATA SPEED CODES

Speed code	Link speed (mph)
1	0-9
2	10-15
3	16-25
4	26-35
5	>35

Source: GCA/Technology Division

APPENDIX G

SUMMARY OF STATIONARY SOURCE INVENTORY

On the following pages is reproduced the summary of Volume II, the inventory of stationary sources of hydrocarbons in the Springfield AQSA.

INTRODUCTION AND SUMMARY

This report, prepared by GCA/Technology Division for the Environmental Protection Agency, Region I, under contract No. 68-02-1376, Task Order No. 15, is a study of the hydrocarbon emission sources in the following three counties in the State of Massachusetts:

Franklin County
Hampshire County
Hampden County.

Throughout this report the three counties will be referred to collectively as the Pioneer Valley.

The main objective was to identify and analyze the types of hydrocarbon emission sources in the Pioneer Valley. The results were a prerequisite for evaluating possible stationary source regulations and were necessary for the development of transportation control strategies for achieving and maintaining the carbon monoxide and photochemical oxidant air quality standards.

In addition to providing the input to the transportation control strategies, the other objectives were to:

- Idenfity point sources for insertion into the National Emission Data System (NEDS) and Compliance Data System (CDS). All area sources are also to be inserted into the NEDS area source file.

- Estimate and summarize the type and quantity of hydrocarbon sources by source category.

- Forecast best estimates of hydrocarbon emissions in 1975, 1977, 1980 and 1985.
- Assess for each industrial category the available emission control technologies, possible reductions in emissions, the cost of reduction measures, and impact on process and energy utilization.

The results and analyses presented in this report are based on an extensive questionnaire survey and discussions with governmental and industrial sources concerned with the manufacture, distribution and control of hydrocarbons. Good cooperation from the industrial sector and the local agency resulted in an extensive survey coverage. It is felt that the results provide a comprehensive and accurate portrayal of hydrocarbon emissions in the study area.

For the purposes of this study, it was assumed that regulations for stationary sources would be similar to the regulations for the Metropolitan Boston Intrastate Air Quality Control Region and that these regulations would take effect on January 1, 1975. The definition of a photochemical reactive solvent as used in this report was taken to be the same as defined in Los Angeles' Rule 66.

IDENTIFICATION OF HYDROCARBON EMISSION SOURCES

Hydrocarbons are emitted by the following major categories: fuel combustion of stationary and transportation sources, solid waste disposal, process and evaporative losses, and other miscellaneous sources. Most of the point and area source information for fuel combustion, transportation, solid waste and miscellaneous were obtained from the existing NEDS file and reviewed. An updated version of area sources by city was obtained from the state agency. It was felt that there was no real need to reexamine with questionnaires these points and area sources because of past emphasis placed on these source categories.

The identification of process and evaporative hydrocarbon point sources was accomplished through the mailing of a questionnaire under the jurisdiction of the state agency, to potential sources with subsequent telephone follow-up of nonrespondents. A point source was defined as one emitting in excess of 40 pounds per day (approximately 5 tons per year). A by-product of the above methodology was the gathering of information on industrial stationary area sources. These emissions along with additional estimates for nonrespondents and others based on statistical solvent usage information, were considered as area source emissions for the pertinent source category and apportioned to each city or town.

For the Pioneer Valley 144 establishments were identified as point sources emitting a total of 14,897 tons per year. Approximately 81 percent of this total is photochemically "reactive" solvent. Fifty-eight of these sources were already identified in the NEDS file, mostly as fuel combustion sources. Of the 86 sources responding to the questionnaire; 69 were industrial process sources, 14 were dry cleaners and 3 were bulk petroleum storage facilities. The industrial survey covered about 60 percent of all the manufacturing firms and 87 percent of all manufacturing employees in the region. Of the 427 industrial firms (in operation during the year 1974) contacted, 379 or 89 percent responded by returning the questionnaire or supplying the information over the telephone. All five questionnaires mailed to bulk storage facilities were returned. Only 51 or 29 percent of the 176 dry cleaning establishments responded by mail. It is estimated that the coverage of industrial point sources for the Pioneer Valley exceeds 90 percent because many firms were excluded from the survey mailing because their operations do not use volatile organic compounds, and because of the plant size bias used in the selection of companies.

Table G-1 summarizes the point and area source hydrocarbon emissions by major source categories. Emissions from all sources totaled 23,635 tons in 1974. Approximately 76 percent or 17,906 tons is considered to be "reactive" hydrocarbons. As illustrated by Figure G-1 the surface coating industry is the major source of hydrocarbon emissions from stationary sources. This category accounted for 63.9 percent of the total. Gasoline marketing was the next largest emitter with 11.4 percent of the total.

Table G-1. SUMMARY OF HYDROCARBON EMISSIONS FOR 1974 IN THE PIONEER VALLEY (tons)

Source category	Point source		Area source emissions	Total emissions
	Number[a]	Emissions		
Dry cleaning	14	97	727	824
Degreasing	27	435	153	588
Surface coating	51	11,427	3,676	15,103
Fabric/Rubber	--	(906)	(59)	(965)
Protective/Decorative	--	(554)	(127)	(681)
Printing	--	(1,969)	(271)	(2,240)
Miscellaneous	--	(7,998)	(672)	(8,670)
Trade paints	--	--	(2,547)	(2,547)
Manufacturing	6	1,713	147	1,860
Bulk petroleum storage	3	915	7	922
Fuel combustion	57	299	552	851
Solid waste incineration	1	11	310	321
Gasoline marketing	NA[b]	NA	2,692	2,692
Aircraft, LTO's	NA	NA	52	52
Railroads and vessels	NA	NA	422	422
Total	159	14,897	8,738	23,635

[a] An establishment may be performing operations in more than one source category. Actually 144 establishments are sources.

[b] NA - Not applicable.

[c] ( )- Subcategories.

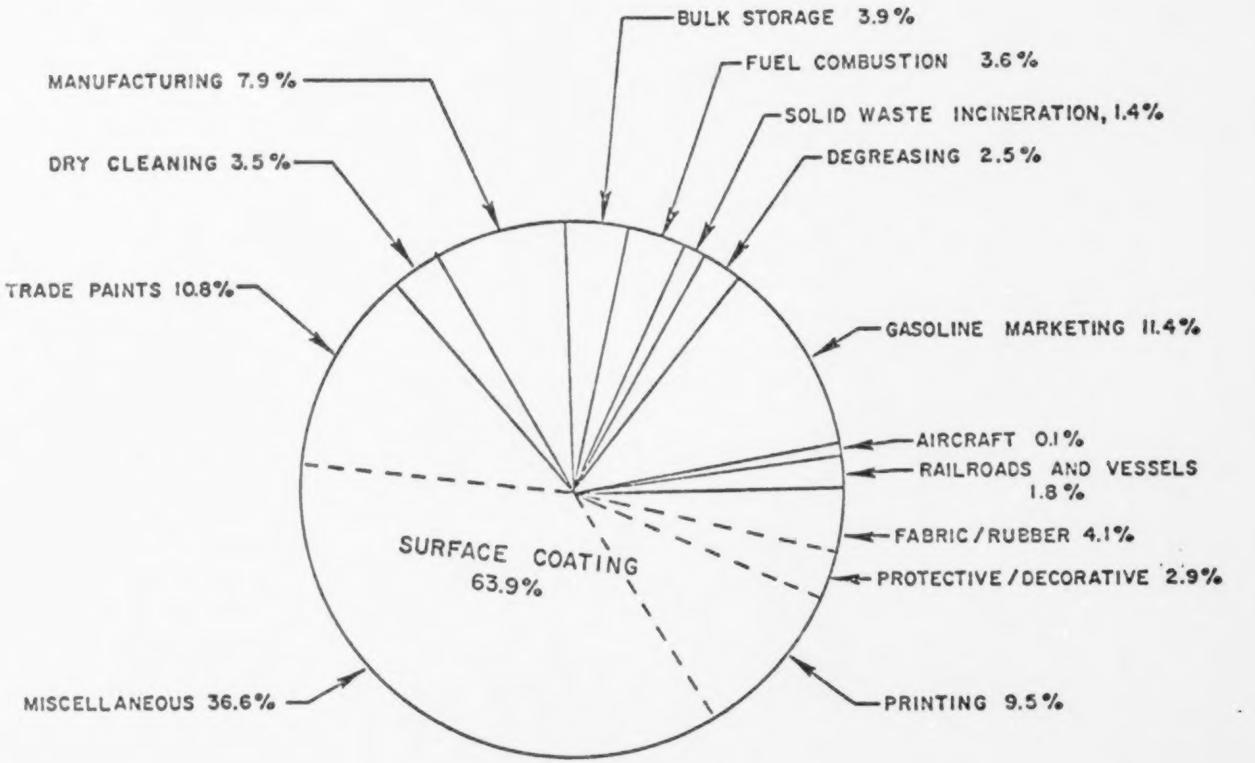

Figure G-1. Distribution of total hydrocarbon emissions except from automobile travel (23,635 tons in 1974) in Pioneer Valley

ANALYSIS OF HYDROCARBON EMISSION BY INDUSTRIAL AND OTHER SOURCE CATEGORIES

To obtain industrial emission estimates, a large number of industrial organizations, trade and professional societies, solvent manufacturers and distributors, and control equipment manufacturers were consulted. In many cases they provided valuable inputs to the program. However, in general, reliable estimates of regional solvent usage were not available from these sources. In many instances it was necessary to provide estimations based on regional or national production, sales and distribution figures published in the statistical literature. Sometimes estimates based on such indicators, unfortunately, did not agree with extrapolation of questionnaire survey results, using the best available scaling factors. In most cases where there was a major disagreement, survey results were used as a basis for final emission estimates. This method appeared to be far more reasonable because of the high percent coverage and response to the questionnaire.

The data obtained from the survey was most useful in relating hydrocarbon emissions to Standard Industrial Classifications (SIC) and industrial operations such as degreasing, dry cleaning, surface coating and manufacturing. The procedures and results of the questionnaire survey are defined in Section III. This section considers hydrocarbon emissions in relationship to SIC Categories for the Region. Since the photochemical reactivity of the hydrocarbon emissions from individual point sources is needed to assess the impact of possible regulations, summaries of emissions by chemical makeup and process type are found in Sections IV through VI.

Dry cleaning emissions (Section IV) were based on estimates provided by a representative of one of the largest suppliers of chlorinated hydrocarbons in the area. These estimates were in good agreement with two other estimation methods: one based on AP-42, the other based on a procedure used by the International Fabricare Institute.

Degreasing emissions (Section V) were based on extrapolating the results of the survey of 100 percent coverage. Chlorinated hydrocarbons made up a high percentage of the total reported degreasing solvent emissions. They accounted for approximately 66 percent of the total. Companies classified with SIC Codes 30 through 36 accounted for about 81 percent of degreasing solvent emissions and about 46 percent of the total manufacturing employees in the Region.

The category of solvent usage in industrial surface coating operations (paints, inks, etc.) was the most difficult to assess. First of all, a wide variety of solvents and dilution factors are used. Secondly, the industrial categories using coatings do so for many purposes and use many different types of coatings. Solvent usage figures were available on a national basis for 1972. However, after they were apportioned to the Pioneer Valley area, they were not in close agreement with the survey results. Estimates of solvent usage for these industrial operations were, therefore, based primarily on survey results extrapolated to 100 percent coverage. One exception was the amount of solvent emitted from trade paints. Since population is an excellent indicator for trade paint sales, the national figure for solvent emitted from trade paints was apportioned on this basis to the Pioneer Valley.

Emissions from manufacturing (Section VII) were based strictly on scaled survey results within pertinent SIC Codes.

In the case of gasoline storage and wholesale distribution, basic data were obtained from state and industrial sources. Estimates based on this data should be reasonably accurate and representative of local conditions. Storage information was also obtained from the major bulk storage sites in the area. As described in Section VIII emission calculations were based on API methods found in the "Compilation of Air Pollution Emission Factors," AP-42.

Other emission categories, fuel combustion and solid waste (Section IX), and exclusively area sources (Section X) are relatively minor, except gasoline distribution, when they are looked at in terms of potential emission reduction by control strategies. Gasoline distribution emissions from service stations were based on state sales figures and emission factors as provided in Supplement No. 1 of EPA Publication AP-42. This emission data is felt to be reliable although certain details of distribution and apportionment may be questionable.

APPORTIONMENT OF EMISSIONS TO COMMUNITIES

The hydrocarbon emissions from point sources identified by the survey were recorded in the appropriate communities of the study area. Estimated area source emissions from industrial and nonindustrial sources were apportioned to each city or town in the study area. Details of the techniques and factors used to estimate and distribute area source emissions to the communities will be found in subsequent sections. Tables similar to Table 1 have been developed for all communities and can be found in Appendix D of this report. These tables provide point and area source emission data for the various source categories.

PROJECTED EMISSIONS AND EFFECTS OF PROBABLE REGULATIONS

Projected emissions through 1985 are shown in Table G-2. These projections are based upon expected growth trends as reported by the Ford Foundation.[1] In order to account for both the past historical growth trends and the uncertainty of government controls on future

Table G-2. PROJECTED TOTAL HYDROCARBON AND PHOTOCHEMICAL "REACTIVE" EMISSIONS FOR THE PIONEER VALLEY BY SOURCE CATEGORY (tons/year)

Category	Annual Growth (%)	1974		1975 No control		1975 With control		1977 No control		1977 With control		1980 No control		1980 With control		1985 No control		1985 With control	
		SSA[a]	PV[b]	SSA	PV	SSA	PV	SSA	PV	SSA	PV	SSA	PV	SSA	PV	SSA	PV	SSA	PV
Dry Cleaning	-1.0	766 (76)[c]	826 (82)	756 (76)	816 (82)	756 (0)	816 (0)	741 (74)	799 (80)	741 (0)	799 (0)	719 (72)	776 (78)	719 (0)	776 (0)	684 (68)	738 (74)	684 (0)	738 (0)
Degreasing	2.5	516 (206)	588 (217)	529 (160)	603 (210)	529 (11)	603 (12)	550 (156)	633 (232)	550 (5)	633 (7)	590 (160)	683 (248)	590 (6)	683 (7)	677 (193)	772 (283)	677 (8)	772 (10)
Fabric/ Rubberized	2.5	961 (948)	985 (972)	985 (972)	989 (976)	150 (145)	159 (145)	1,036 (1,020)	1,039 (1,025)	166 (152)	167 (153)	1,114 (1,099)	1,119 (1,104)	180 (166)	181 (166)	1,261 (1,244)	1,266 (1,249)	203 (187)	204 (187)
Protective/ Decorative	2.5	636 (603)	682 (650)	650 (618)	699 (664)	287 (63)	310 (72)	683 (640)	734 (700)	330 (66)	375 (65)	735 (698)	791 (754)	355 (69)	404 (71)	832 (791)	895 (854)	384 (77)	458 (82)
Printing	2.5	2,155 (367)	2,238 (378)	2,209 (377)	2,295 (383)	1,740 (11)	1,821 (13)	2,321 (395)	2,411 (401)	1,735 (28)	1,819 (31)	2,499 (426)	2,507 (433)	1,847 (30)	1,938 (36)	2,828 (482)	2,938 (490)	2,113 (35)	2,215 (38)
Miscellaneous Coating	2.5	7,309 (7,090)	8,494 (8,404)	7,492 (7,153)	8,511 (8,066)	2,161 (1,717)	2,276 (1,876)	7,871 (7,201)	9,362 (8,961)	2,912 (2,313)	3,444 (2,851)	8,476 (7,030)	10,082 (9,700)	3,103 (2,463)	3,691 (3,037)	9,593 (8,866)	11,407 (10,841)	3,509 (2,783)	4,175 (3,435)
Trade Paints	2.5	2,222 (667)	2,567 (766)	2,278 (683)	2,611 (783)	2,278 (23)	2,611 (26)	2,393 (718)	2,743 (823)	2,393 (72)	2,743 (82)	2,577 (773)	2,956 (886)	2,577 (77)	2,956 (89)	2,915 (875)	3,342 (1,003)	2,915 (88)	3,342 (100)
Manufacturing	2.5	1,818 (1,100)	1,860 (1,137)	1,864 (1,148)	1,907 (1,155)	556 (280)	558 (288)	1,990 (1,206)	2,001 (1,216)	506 (204)	509 (207)	2,143 (1,299)	2,157 (1,307)	642 (319)	647 (322)	2,425 (1,469)	2,440 (1,478)	745 (370)	750 (381)
Bulk Petroleum	0 1974-75 -2.5 1975-85	921 (921)	922 (922)	132 (132)	133 (133)	92 (92)	92 (92)	125 (125)	126 (126)	88 (88)	88 (88)	115 (115)	116 (116)	81 (81)	81 (81)	103 (103)	104 (104)	72 (72)	72 (72)
Gasoline Marketing	0 1974-75 -2.5 1975-85	2,271 (2,271)	2,692 (2,692)	2,273 (2,273)	2,602 (2,602)	227 (227)	260 (260)	2,101 (2,101)	2,550 (2,550)	216 (216)	256 (256)	2,003 (2,003)	2,372 (2,372)	200 (200)	237 (237)	1,765 (1,765)	2,090 (2,090)	177 (177)	209 (209)
Fuel Combustion	1.9	782 (782)	811 (811)	797 (797)	847 (847)	797 (797)	847 (847)	827 (827)	900 (900)	827 (827)	900 (900)	876 (876)	953 (953)	876 (876)	953 (953)	962 (962)	1,047 (1,047)	962 (962)	1,047 (1,047)
Incineration	0.7	294 (294)	321 (321)	300 (300)	323 (323)	300 (300)	323 (323)	306 (306)	328 (328)	306 (306)	328 (328)	311 (311)	335 (335)	311 (311)	335 (335)	322 (322)	347 (347)	322 (322)	347 (347)
Aircraft	6.0	48 (48)	52 (52)	51 (51)	55 (55)	51 (51)	55 (55)	57 (57)	62 (62)	57 (57)	62 (62)	68 (68)	74 (74)	68 (68)	74 (74)	91 (91)	99 (99)	(91) (91)	(99) (99)
Railroads/ Vessels	3.3	185 (188)	622 (622)	195 (195)	637 (637)	195 (195)	637 (637)	208 (208)	666 (666)	208 (208)	668 (668)	231 (231)	519 (519)	231 (231)	519 (519)	276 (276)	616 (616)	276 (276)	616 (616)
TOTAL		20,619 (15,516)	21,659 (17,986)	20,566 (16,923)	22,118 (17,396)	10,115 (3,880)	11,042 (4,453)	21,271 (15,183)	26,167 (17,619)	11,110 (4,630)	12,601 (5,376)	22,465 (15,978)	25,327 (18,870)	11,006 (4,097)	13,492 (3,625)	24,720 (17,385)	28,101 (20,375)	13,128 (5,418)	15,646 6,423

[a] SSA = Springfield Study Area

[b] PV = Pioneer Valley

[c] ( ) = Photochemical "reactive" hydrocarbons

energy needs an average growth rate of 2.5 percent was used for all manufacturing industries.[1] Growth rates for other sources of hydrocarbon emissions are presented in Table G-3.

Table G-3. ANNUAL GROWTH RATES FOR OTHER SOURCES OF HYDROCARBON EMISSIONS

Category	Annual growth rate (%)
Dry Cleaning	-1.5[2]
Gasoline Marketing	0 (1974-1975)
	-2.5 (1975-1985)[3]
Fuel Combustion	1.9[4]
Incineration	0.7[5]
Aircraft	6.0[6]
Railroads and Vessels	3.5[7]

As seen by Table G-2, significant reductions in total hydrocarbon and photochemical "reactive" hydrocarbons will be achieved in the Pioneer Valley due to probable regulations. Because of reformulation of existing solvent mixtures and avoidance of control by those emitting less than 40 pounds per day, reductions of photochemical "reactive" hydrocarbons will initially be large and then stabilize. Only a slight increase can be expected due to expansion of currently existing companies and to the development of new firms. By 1975 photochemical "reactive" hydrocarbon emissions will decrease by 75 percent (due to probable regulations) from 17,906 tons to 4,453 tons. The decrease in total hydrocarbon emissions will be 48 percent by 1975 and will once again grow with industrial indicators. Emissions for 1977, 1980 and 1985 with and without probable regulations are also shown in Table 2. It was assumed that the regulations would be immediately effective and compliance would be achieved by January 1, 1975. A definition of photochemically "reactive" hydrocarbons was taken from the regulations for the Metropolitan Boston Intrastate Air Quality Control Region, which are similar to Los Angeles' Rule 66. The criteria for classifying the hydrocarbon mixture as "reactive" were applied only to the emissions from point sources. The ratio of reactive emissions to total emissions from point sources was then used to determine the amount of reactive hydrocarbons that can be expected from the area sources in each major category.

Compliance in the dry cleaning, degreasing, manufacturing and surface coating operations will be achieved primarily by reformulation of existing solvent mixtures rather than through the installation of control equipment. This option is technically feasible, in most instances, and will be followed by most industrial users of solvents. However, some of the larger users of industrial coatings will have to install control equipment. Sometimes such action is economically viable as indicated by the several cases presented in this report and the fact that three large establishments already have recovery control equipment in the study area.

The impact of the probable regulations on petroleum products, (mainly gasoline) storage and distribution will reduce the photochemical "reactive" hydrocarbon emissions in the Pioneer Valley by approximately 14 percent. Most of this reduction will be accomplished at the retail level by a vapor recovery system on stationary storage vessels and during the filling of vehicle storage tanks. Emissions could be reduced 90 percent, from 2692 tons to 269 tons at gasoline service stations (507) if this type of regulation is adopted. Losses from bulk gasoline storage are currently being reduced by one larger supplier in the area. It is expected that emissions from both storage tank losses and loading rack losses from this company will be reduced by at least 90 percent. If a regulation is applied to all bulk distributors, emissions will drop from 922 tons in 1974 to 92 tons in 1975.

Emissions from all other categories will increase with their respective growth rates. Although these emissions are minor they were classified as photochemical "reactive" because they evolve from combustion at high temperatures. Because of the inadequate information available about the photochemical "reactivity" of the numerous hydrocarbon compounds, on which research is actively proceeding, we believe that the above assumptions are subject to change as more knowledge in this area becomes available.[8] Therefore, the reductions for photochemical "reactive" hydrocarbons should not be construed as exact values.

APPENDIX H

TRAVEL PROJECTIONS

The following Tables present projections of travel and distribution of travel by highway facility type through 1990.

Table H-1. TRAVEL PROJECTIONS AS DAILY VEHICLE-MILES OF TRAVEL, 1973 THROUGH 1990, FRANKLIN COUNTY

Year	Vehicle-miles of travel by vehicle type						
	LDV	LDT	HDV	MC	LDDV	HDDV	Total
1973	881,741	142,025	59,177	4,718	1,200	94,684	1,183,545
1974	908,193	146,286	60,959	4,873	1,239	97,524	1,222,410
1975	935,439	150,674	62,780	5,028	1,279	100,450	1,261,277
1976	963,502	155,194	64,664	5,183	1,318	103,463	1,300,143
1977	992,407	159,850	66,604	5,338	1,358	106,567	1,339,008
1978	1,022,179	164,646	68,602	5,493	1,397	109,763	1,377,874
1979	1,052,844	169,585	70,660	5,648	1,437	113,057	1,416,740
1980	1,084,430	174,673	72,780	5,803	1,476	116,449	1,455,606
1981	1,109,047	178,638	74,432	5,949	1,513	119,092	1,492,236
1982	1,134,222	182,693	76,121	6,095	1,550	121,796	1,528,866
1983	1,159,969	186,840	77,850	6,241	1,587	124,561	1,565,495
1984	1,186,300	191,082	79,617	6,387	1,624	127,388	1,602,125
1985	1,213,229	195,419	81,424	6,533	1,662	130,280	1,638,755
1986	1,240,769	199,855	83,272	6,679	1,698	133,237	1,675,385
1987	1,268,935	204,391	85,163	6,825	1,736	136,262	1,712,015
1988	1,297,740	209,032	87,096	6,971	1,773	139,354	1,748,645
1989	1,327,198	213,777	89,073	7,117	1,810	142,518	1,785,275
1990	1,357,326	218,629	91,091	7,263	1,847	145,753	1,821,904

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

GCA/Technology Division

TABLE H-2. TRAVEL PROJECTIONS AS DAILY VEHICLE-MILES OF TRAVEL, 1973 THROUGH 1990, HAMPDEN COUNTY

Year	Vehicle-miles of travel by vehicle type						
	LDV	LDT	HDV	MC	LDDV	HDDV	Total
1973	4,292,467	691,404	288,085	23,046	5,762	460,936	5,761,700
1974	4,439,637	715,109	297,962	23,837	5,960	476,739	5,959,243
1975	4,586,807	738,815	307,839	24,627	6,159	492,543	6,156,788
1976	4,733,978	762,520	317,716	25,416	6,354	508,347	6,354,331
1977	4,881,148	786,225	327,593	26,204	6,552	524,150	6,551,874
1978	5,028,318	809,930	337,471	26,997	6,750	539,954	6,749,420
1979	5,175,489	833,636	347,348	27,787	6,947	555,757	6,946,964
1980	5,322,659	857,341	357,225	28,578	7,145	571,561	7,144,508
1981	5,443,483	876,803	365,334	29,266	7,307	584,535	7,306,688
1982	5,564,308	896,264	373,443	29,875	7,469	597,510	7,468,869
1983	5,685,132	915,726	381,552	30,523	7,631	610,484	7,631,049
1984	5,805,957	935,187	389,661	31,173	7,794	623,459	7,793,231
1985	5,926,781	954,649	397,770	31,821	7,956	636,433	7,955,409
1986	6,047,605	974,111	405,879	32,469	8,118	649,407	8,117,590
1987	6,168,430	993,572	413,988	33,118	8,280	662,382	8,279,700
1988	6,289,254	1,013,033	422,097	33,766	8,442	675,356	8,441,980
1989	6,410,079	1,032,495	430,206	34,416	8,605	668,331	8,604,131
1990	6,530,903	1,051,957	438,315	35,064	8,767	701,305	8,766,311

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

Table H-3. TRAVEL PROJECTIONS AS DAILY VEHICLE-MILES OF TRAVEL, 1973 THROUGH 1990, HAMPSHIRE COUNTY

Year	Vehicle-miles of travel by vehicle type						
	LDV	LDT	HDV	MC	LDDV	HDDV	Total
1973	1,139,044	183,470	76,446	6,115	1,529	122,313	1,528,918
1974	1,178,097	189,760	79,067	6,325	1,581	126,507	1,581,338
1975	1,217,150	196,051	81,688	6,534	1,634	130,700	1,633,758
1976	1,256,203	202,341	84,309	6,744	1,686	134,894	1,686,178
1977	1,295,256	208,632	86,930	6,954	1,738	139,087	1,738,598
1978	1,334,309	214,922	89,551	7,163	1,791	143,281	1,791,018
1979	1,373,362	221,213	92,172	7,373	1,843	147,474	1,843,438
1980	1,412,415	227,503	94,793	7,582	1,896	151,668	1,895,858
1981	1,444,477	232,667	96,945	7,755	1,939	155,111	1,938,894
1982	1,476,539	237,832	99,097	7,926	1,982	158,554	1,981,930
1983	1,508,600	242,996	101,248	8,099	2,025	161,997	2,024,966
1984	1,540,662	248,160	103,400	8,270	2,068	165,440	2,068,002
1985	1,572,724	253,325	105,552	8,443	2,111	168,883	2,111,038
1986	1,604,786	258,489	107,704	8,616	2,154	172,325	2,154,074
1987	1,636,848	263,653	109,856	8,787	2,197	175,768	2,197,110
1988	1,668,909	268,817	112,007	8,960	2,240	179,211	2,240,046
1989	1,700,971	273,982	114,159	9,128	2,282	182,654	2,283,182
1990	1,733,033	279,146	116,311	9,304	2,326	186,097	2,326,218

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

GCA/Technology Division

Table H-4. FRACTIONAL DISTRIBUTION OF VMT BY HIGHWAY TYPE, 1973 THROUGH 1990, FRANKLIN COUNTY

Year	Fraction of total VMT performed by facility		
	Freeway	Arterials/ collectors	Local
1973	0.2325	0.7059	0.0616
1974	0.2325	0.7059	0.0616
1975	0.2325	0.7059	0.0616
1976	0.2325	0.7059	0.0616
1977	0.2325	0.7059	0.0616
1978	0.2325	0.7059	0.0616
1979	0.2325	0.7059	0.0616
1980	0.2325	0.7059	0.0616
1981	0.2325	0.7059	0.0616
1982	0.2325	0.7059	0.0616
1983	0.2325	0.7059	0.0616
1984	0.2325	0.7059	0.0616
1985	0.2325	0.7059	0.0616
1986	0.2325	0.7059	0.0616
1987	0.2325	0.7059	0.0616
1988	0.2325	0.7059	0.0616
1989	0.2325	0.7059	0.0616
1990	0.2325	0.7059	0.0616

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

GCA/Technology Division

Table H-5. FRACTIONAL DISTRIBUTION OF VMT BY HIGHWAY TYPE, 1973 THROUGH 1990, HAMPDEN COUNTY

Year	Fraction of total VMT performed by facility Freeway	Arterials/ collectors	Local
1973	0.2704	0.6842	0.0454
1974	0.2746	0.6765	0.0489
1975	0.2789	0.6687	0.0524
1976	0.2831	0.6610	0.0559
1977	0.2873	0.6533	0.0594
1978	0.2915	0.6456	0.0629
1979	0.2958	0.6377	0.0665
1980	0.3000	0.6300	0.0700
1981	0.3000	0.6270	0.0730
1982	0.3000	0.6240	0.0760
1983	0.3000	0.6210	0.0790
1984	0.3000	0.6180	0.0820
1985	0.3000	0.6150	0.0850
1986	0.3000	0.6120	0.0880
1987	0.3000	0.6090	0.0910
1988	0.3000	0.6060	0.0940
1989	0.3000	0.6030	0.0970
1990	0.3000	0.6000	0.1000

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

GCA/Technology Division

Table H-6. FRACTIONAL DISTRIBUTION OF VMT BY HIGHWAY TYPE, 1973 THROUGH 1990, HAMPSHIRE COUNTY

Year	Fraction of total VMT performed by facility		
	Freeway	Arterials/ collectors	Local
1973	0.1027	0.8242	0.0731
1974	0.1066	0.8172	0.0762
1975	0.1106	0.8101	0.0793
1976	0.1144	0.8031	0.0825
1977	0.1183	0.7961	0.0856
1978	0.1222	0.7891	0.0887
1979	0.1261	0.7820	0.0919
1980	0.1300	0.7750	0.0950
1981	0.1305	0.7715	0.0980
1982	0.1310	0.7680	0.1010
1983	0.1315	0.7645	0.1040
1984	0.1320	0.7610	0.1070
1985	0.1325	0.7575	0.1100
1986	0.1330	0.7540	0.1130
1987	0.1335	0.7505	0.1160
1988	0.1340	0.7470	0.1190
1989	0.1345	0.7435	0.1220
1990	0.1350	0.7400	0.1250

Source: Massachusetts Department of Public Works, Bureau of Transportation Planning and Development.

GCA/Technology Division

Table H-7. AVERAGE SPEED BY HIGHWAY TYPE FOR ALL YEARS FROM 1973 THROUGH 1990, FRANKLIN, HAMPDEN, AND HAMPSHIRE COUNTIES

County	Average speed by highway-type (all years)		
	Freeway	Arterials/ collectors	Local
Franklin	50	40	35
Hampden	50	40	30
Hampshire	50	40	30

Source: GCA/Technology Division

APPENDIX I

DRAFT TCP REGULATIONS

INTRODUCTION

This appendix presents draft regulations for the proposed elements of the Transportation Control Plan. Regulations for stationary source controls are described in Volume II, published separately.

The form and content of these draft regulations are based upon EPA regulations for other TCP's, and in particular upon the latest proposed regulations for Boston wherever possible.

These regulations, when adopted by EPA, would be part of Subpart W, Part 52, Chapter I, Title 40, of the Code of Federal Regulations. In some cases, approximate dates are suggested here. Such dates should be considered tentative and should be reviewed by appropriate authorities before adoption or promulgation.

REGULATION FOR COMPUTER CARPOOL MATCHING

The following draft regulation is based upon the corresponding regulation for the Boston Intrastate AQCR proposed by EPA in the Federal Register of June 12, 1975 (at 40 CF 25163).

It should be noted that, if participation in the carpooling program becomes mandatory, an additional regulation will be required. In all probability, this regulation would be identical to a regulation for the Boston Intrastate TCP (see 40 CF 25166-25168).

§52.XXXX Regulation for computer carpool matching.

(a) "Carpool matching" means assembling lists of commuters with similar daily travel patterns and providing a mechanism by which persons on such lists may be put in contact with each other for the purpose of forming carpools.

(b) This section is applicable in the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region.

(c) The Governor of the Commonwealth of Massachusetts or a properly authorized department of the executive branch thereof shall establish a program for encouraging employees and educational institutions to set up carpool matching programs within facilities under their control. The program shall provide for:

(1) The distribution by October 1, 1975, to each employer in the Region with more than 250 employees and to each educational institution in the Region with 250 or more employees and students, and to any other interested employer or educational institution, of a manual adequately showing how to establish and maintain a carpool program;

(2) A computer program available by October 1, 1975, to any such employer or educational institution or group for the purpose of carpool matching by use of such computer program;

(3) Processing by the Commonwealth by October 1, 1975, of any set of properly prepared computer cards for 400 or more commuters submitted by any such employer or educational institution;

(4) Distributing the results of any computer carpool matching to the person or persons who submitted the unprocessed cards;

(5) Full-time guidance and technical consulting to the affected facilities available by October 1, 1975, in order to initiate and maintain the carpooling program.

REGULATION FOR TRAFFIC FLOW MANAGEMENT

§52.XXXX Regulation for traffic flow management in the Springfield Central Business District

(a) A traffic flow management program shall be undertaken in the Springfield Central Business District. The program shall improve traffic flow in the Central Business District in such a manner as to reduce concentrations of carbon monoxide.

(b) The Governor of the Commonwealth of Massachusetts or a properly authorized department of the executive branch thereof shall submit to the Administrator for his approval a detailed statement of the steps taken to implement the actions in paragraphs (a) and (c) of this section, and a schedule for such implementation.

(c) The traffic flow management program shall, as a minimum, include the following actions:

(1) Changing the flow patterns so that the following streets carry traffic in one direction only, in the direction indicated:

(i) Union Street, between Main Street and West Columbus, westbound.

(ii) East Court Street, between Main and Market Streets, eastbound.

(iii) Court Street, between Main Street and East Columbus, westbound.

(iv) Main Street, between State Street and Liberty Streets, northbound (except that operation of a contra-flow bus lane shall be permitted).

(v) State Street, between West Columbus and Main Street, eastbound.

(2) Closing the following street sections to any traffic other than delivery vehicles and emergency vehicles:

(i) Pynchon Street, between Main Street and City Hall Drive.

(ii) Hillman Street, between Main Street and Barnes Street.

(iii) Bridge Street, between Main Street and Barnes Street.

(iv) Gridiron Street, between Main Street and the entrance to a parking facility at 35 Gridiron Street.

(3) Close Lyman Street between Main Street and Dwight Street to any traffic other than delivery vehicles, emergency vehicles, and vehicles seeking access to the AMTRAK station.

(4) Prohibition of parking along the curbs of the following streets.

(i) Worthington Street between East Columbus Avenue and Dwight Street.

(ii) Hillman Street, between Main Street and Dwight Street.

(iii) Harrison Avenue, between Main Street and Dwight Street.

(iv) Main Street, between Union Street and Congress Street.

(v) Taylor Street, between Main Street and Powers Street.

(vi) Chestnut Street, between State Street and Lyman Street.

(5) Prohibition of commercial goods pickup or delivery in the downtown area during the hours between 3:30 p.m. to 5:30 p.m. on weekdays.

(6) Necessary and appropriate traffic engineering actions consistent with other aspects of the program, including but not necessarily limited to adjustments of existing traffic signal systems, installation of additional traffic signals or signal control systems, and minor geometric changes to streets.

(7) Develop a low-cost parking facility under I-291 in the vicinity of Main Street for long-term parkers. Also, provide bus shuttle service between this facility and various points in downtown Springfield.

(d) In submitting the program to the Administrator as required by paragraph (b) of this section, the Governor or his designee shall:

(1) Submit the specific regulations and ordinances enacted by the City of Springfield to implement this program.

(2) Provide a program that shall be operational by July 1, 1976.

REGULATION FOR INSPECTION AND MAINTENANCE

§ 52.XXXX Regulation for Inspection and Maintenance

(a) Definitions:

(1) "Inspection and maintenance program" means a program to reduce emissions from in-use vehicles through identifying vehicles that need emission control-related maintenance and requiring that such maintenance be performed.

(2) "Light-duty vehicle" means a gasoline-powered motor vehicle rated at 6,000 lb GVW or less.

(3) "Medium-duty vehicle" means a gasoline-powered motor vehicle rated at more than 6,000 lb GVW and less than 10,000 lb GVW.

(b) This section is applicable in the Massachusetts portion of the Hartford-New Haven-Springfield Interstate Region

(c) The Commonwealth shall establish an inspection and maintenance program applicable to all gasoline-powered light-duty and medium-duty vehicles registered in the Region that operate on streets and highways over which it has jurisdiction. No later than April 1, 1976, the Commonwealth shall submit legally adopted regulations to the Regional Administrator establishing such a program. Antique motor vehicles designated by the appropriate state registration procedures shall be exempt from the requirements of this section. The regulation shall include:

(1) Provisions for inspection of all such motor vehicles by means of an idle emission test at periodic intervals at least once each year on a rotating schedule which provides for inspection of all such vehicles over a 12-month period with the first segment of such schedule commencing on August 1, 1976.

(2) Provisions for establishing and periodically revising emission limitations approved by the Regional Administrator to be in effect at all times which are designed to achieve an overall annual reduction in vehicular emissions within the Region of 11 percent of hydrocarbons (exhaust portion) and 9 percent of carbon monoxide which would otherwise be emitted.

(3) Provisions to require that failed vehicles receive, within 2 weeks, the maintenance necessary to achieve compliance with the inspection standards. This shall include sanctions against noncomplying individual owners and repair

facilities, retest of failed vehicles following maintenance, a certification program to insure that repair facilities performing the required maintenance have the necessary equipment, parts and knowledgeable technicians to perform the tasks satisfactorily, and such other measures as may be necessary or appropriate.

(4) A program of enforcement, such as a spot check of idle adjustment, to insure that, following maintenance, vehicles are not subsequently readjusted or modified in such a way as would cause them no longer to comply with the inspection standards. This program shall include appropriate penalties for violation.

(5) Designation of an agency or agencies responsible for conducting, overseeing, and enforcing the inspection and maintenance program.

(d) Commencing August 1, 1976, the State shall not register or allow to operate on its highways any light-duty vehicle or medium-duty vehicle that does not comply with the applicable standards and procedures adopted pursuant to paragraph (c) of this section. This shall not apply to the initial registration of a new motor vehicle.

(e) Commencing August 1, 1976, no owner of a light-duty or medium-duty vehicle shall operate or allow the operation of any such vehicle that does not comply with the applicable standards and procedures adopted pursuant to paragraph (c) of this section. This shall not apply to the initial registration period of a new motor vehicle.

(f) The Commonwealth of Massachusetts shall submit, no later than September 1, 1975, a detailed compliance schedule showing the steps it will take to establish and enforce an inspection and maintenance program pursuant to paragraph (c) of this section, including the text of any needed statutory proposals, and needed regulations that it will propose for adoption. The compliance schedule shall also include:

(1) The date by which the Commonwealth will recommend the needed legislation to the legislature;

(2) The date by which the necessary equipment will be ordered;

(3) A statement from the Governor identifying the sources and amounts of funds for the program. If the program cannot legally be funded or implemented under existing statutory authority, the text of needed legislation must be submitted.

(g) The Commonwealth shall submit, no later than September 1, 1975, the text of any needed statutory proposals or regulations to ensure that the inspection and maintenance system contains safeguards to protect consumers, including (but not limited to):

(1) Upgrading of the current procedures and requirements for certification of inspection stations to provide that the operators and employees performing such work on vehicles are responsible and competent to do so; and

(2) Protection of consumers from loss due to negligent performance of inspection and related maintenance work.

REGULATION FOR MONITORING

The following is based upon the corresponding regulation proposed by EPA for the Boston Intrastate Region (40 CF 25166, June 12, 1975).

§ 52.XXXX Monitoring reports.

(a) All definitions are as used in 40 CFR 51.19.

(b) This regulation is applicable in the Massachusetts portion of the Hartford-New Haven-Springfield Air Quality Control Region.

(c) The Commonwealth of Massachusetts or an agency designated by the Commonwealth and approved by the Administrator, shall monitor the emission reduction occurring as a result of inspection and maintenance programs required under §52.XXXX, and as a result of the traffic flow management program and carpool program required by §52.XXXX through §52.XXXX.

(d) The Commonwealth of Massachusetts shall review its existing air quality monitoring program and modify it as necessary so as to provide an adequate basis for the annual review by the Administrator required under paragraph (i) of this section. At a minimum the Commonwealth shall review the number and placement of monitoring stations, the types of pollutants and meteorological parameters measured, and shall devise a comprehensive quality assurance program for all phases of the monitoring program.

(e) The Commonwealth of Massachusetts shall review its existing traffic monitoring program and modify it was necessary so as to provide reliable information about vehicle miles traveled and traffic patterns in all critical areas, and shifts in traffic patterns and vehicle miles traveled so as to better correlate traffic data with air quality measurements. Vehicle miles traveled information shall be based on representative traffic counts taken within the Region and shall be correlated with each applicable control measure designated in this plan.

(f) No later than (date to be determined by EPA) the Governor or his designee shall submit a report to the Regional Administrator containing detailed information demonstrating compliance with paragraphs (c), (d) and (e) of this section. The information contained in this report shall include as a minimum:

(1) The administrative process to be used and the agency or agencies responsible for conducting, overseeing and maintaining the monitoring programs in paragraphs (c), (d) and (e) of this section;

(2) A description of the revised ambient air monitoring network, equipment operating and data reporting procedures, and quality assurance programs to be used to insure the routine collection of valid, reliable and representative air quality data;

(3) A description of the revised traffic monitoring program; and

(4) All other information necessary to describe the methods to be used to collect the required data.

(g) The Governor or his designee shall submit a report to the Regional Administrator annually, beginning on (date to be determined by EPA) and containing the results of the monitoring program approved in paragraph (f) of this section. This report shall include at a minimum appropriate air quality and meteorological data, average vehicle miles traveled data, an appropriate analysis of the data base, and summary information on travel changes as required by §52.XXXX of this subpart.

This report shall be submitted in a form acceptable to the Regional Administrator. In addition all air quality data will be submitted quarterly to the Administrator by the Commonwealth as required by 40 CFR 51.7.

(h) Monitoring, quality assurance programs, reporting and other procedures and methodologies required by this section shall be subject to the approval of the Regional Administrator.

(i) Upon receipt of the annual report required by paragraph (g) of §52.XXXX, the Regional Administrator shall analyze it and determine whether the emission reduction is in substantial conformity with the projections which formed the technical basis for the promulgation of transportation controls for the Region. If the Administrator determines that the emission reductions are substantially less than or are substantially in excess of those required to meet air quality standards, the Administrator shall, after adequate public notice and public hearings, amend the regulations in such transportation control plan so as to avoid substantially implementing a plan which is either substantially more or substantially less rigorous than that required to meet ambient air quality standards.

(j) On or before February 15, 1976, and on each succeeding February 15 thereafter the Governor of Massachusetts or his designee shall submit to the Administrator a report listing each project for expanding or improving mass transit facilities which is then under construction or is being proposed to be constructed within the Region, together with a listing of the reductions in vehicle miles (i) estimated to result from such project and (ii) estimated to result from all projects as an aggregate.

REGULATION FOR STATIONARY SOURCE EMISSIONS CONTROLS

No regulation is proposed here for controlling emissions from stationary sources. Volume II of the report indicated that the controls proposed for the AQCR were based on controls proposed for the Boston Transportation Control Plan. These proposed regulations with changes are presented in Volume II.

REGULATION FOR CARBON MONOXIDE HOT SPOT IDENTIFICATION

§ 52.XXXX Localized High Concentrations - Carbon Monoxide

(a) Not later than (date to be determined by EPA) the Commonwealth shall have developed and have begun to implement a program to identify urban and suburban core areas and roadway/intersection complexes within the Region which violate the national ambient air quality standards for carbon monoxide. Once such localized areas have been identified, the Commonwealth, in cooperation with the affected local municipalities, shall develop and implement appropriate control strategies to insure that such air quality standards will be achieved at such areas. Plans shall be developed to include provisions for the entire municipality in order to insure that the implemented strategies will not create carbon monoxide violations elsewhere in the vicinity after the measures have been applied.

(b) To accomplish the requirements of paragraph (a) of this section, the Commonwealth shall do the following:

(1) Identify areas of potentially high carbon monoxide concentrations by reviewing all available traffic data, physical site data and air quality and meteorological data for all major intersections and roadway complexes within the Region. The Regional Administrator will provide general guidance on area designations to assist in the initial identification process.

(2) Areas identified under paragraph (b) (1) of this section shall be studied in further detail, including meteorological modeling, traffic flow monitoring, air quality monitoring and other measures necessary to accurately quantify the extent and actual levels of carbon monoxide in the area. A report containing the results of these analyses and identifying such areas shall be submitted to the Regional Administrator no later than (date to be determined by EPA).

(3) If, after the completion of actions required by paragraph (b) (2) of this section, an area shows or is predicted to have violations of the carbon monoxide standard, the Commonwealth, in cooperation with the affected municipality, shall submit a plan to the Regional Administrator containing measures to regulate traffic and parking so as to reduce carbon monoxide emissions to achieve air quality standards in the area. Such plan shall include: the name of the agency responsible for implementing the plan, all technical data and analyses supporting the conclusions of the plan, all control strategies adopted as part of the plan, and other such information relating to the proposed program as may be required by the Regional Administrator. The Regional Administrator shall provide general guidance on applicable control strategies and reporting formats to assist in plan development and submittal. Such a plan shall be submitted for each municipality which contains one or more identified areas no later than (date to be determined by EPA).

(4) All measures called for in the plan submitted under paragraph (b) (3) of this section shall be subject to the approval of the Regional Administrator and shall be implemented by (date to be determined by EPA).

(c) The Commonwealth shall annually review the effectiveness of the control strategies developed pursuant to this section and modify them as necessary to insure that such carbon monoxide standards will be attained and maintained. The results of this review and any changes in the measures which the Commonwealth recommends as a result thereof shall be reported to the Regional Administrator annually as required under § 52.XXXX.

(d) Prior to submitting any plan to the Regional Administrator under paragraph (b) (3), the Commonwealth shall give prominent public notice of the general recommendations of such plan, shall make such plan available to the public for at least 30 days and permit any affected public agency or member of the public to comment in writing on such plan. The Commonwealth shall give the Regional Administrator timely notice of any public hearing to be held on such plan and shall make all comments received available to the Regional Administrator for inspection and copying.

APPENDIX J

PROPOSED TRANSIT IMPROVEMENT PLAN IMPLEMENTATION SCHEDULE

The following presents the proposed timetable for implementing transit improvements, extracted from the report entitled Transit Improvement Program for the Lower Pioneer Valley, Massachusetts, by Wilbur Smith and Associates, February 1974.

This schedule is reproduced here for information purposes but should be considered tentative. Actual schedules for implementation of these or other transit measures will be the responsibility of the regional transit authority.

YEAR MEASURES TO BE TAKEN

1974

1. Organize Lower Pioneer Valley Transit District, to contain the following towns:

    Agawam
    Amherst
    East Longmeadow
    Longmeadow
    Springfield-Ludlow
    Westfield
    West Springfield

2. Establish management, recruit staff, establish accounting, audit, surveillance and reports system.

3. Institute route changes as follows:

    (1) Route 01, turnback, Chicopee Center - Sumner and Allen via Main -- substitute Route 4.
    (2) Route 03, Chicopee Falls - Wilbraham Road via Liberty -- reroute to Dickinson (Route 5).
    (3) Route 04, Springfield and Rimmon-King Street -- change to Chicopee Center - Allen and Cooley via Springfield and Chestnut/Dwight.
    (4) Route 05, Plainfield-Dickinson -- change to Brightwood-King Street.
    (5) Routes 06 and 10, Ludlow and Westfield -- combine, at least for base service (Route 08).
    (6) Route 07, State Street -- change number to 11.
    (7) Route 08, College-Walnut-Plumtree -- change number to 14.
    (8) Route 09, St. James -- combine with 15 (Worthington) to form new Route 16.
    (9) Institute express service between Westfield and Springfield via. Mass. Turnpike (New Route 10).
    (10) Route 11, Springfield-Holyoke via Riverdale -- change number to 17, add 1 bus.
    (11) Route 12, North Wilbraham-Springfield Express -- increase frequency of service.
    (12) Route 13, Maple -- change number to 19, increase frequency of service.
    (13) Route 16, Memorial Avenue -- change to Wilbraham Road-Eastern States Exposition Grounds (Parking Lot) to form new Route 13.
    (14) Route 20, Mt. Holyoke - Springfield Express -- increase frequency of service.
    (15) Route 21, Feeding Hills -- reschedule for more convenience to potential riders.
    (16) Route 24, East Longmeadow-Springfield -- add Milton Bradley routes to public timetable for this service.
    (17) Route 27, Springfield-Hampden Express -- increase frequency of service.
    (18) Route 28, Ludlow-Milton Bradley -- add to public timetable.
    (19) Route 31, Holyoke-Brightwood via Spaulding -- initiate service.
    (20) Holyoke Route 2, Springfield Express -- reschedule for more convenience to potential passengers (Run 6 AM - 9 AM, 2 PM - 6 PM, 60-minute headway).
    (21) Holyoke Routes 5 and 8, Fairview and Westover -- combine to form new Route 35.
    (22) Holyoke Routes 6 and 16, South Hadley Center and Elmwood-Oakdale -- Combine to form new Route 36.
    (23) Holyoke Route 12, Easthampton via Northampton -- abandon service on U.S. Route 5 north of Mountain Park Road, reroute all Holyoke-Northampton local buses via Easthampton (new Route 39).
    (24) Institute service to new Holyoke Community College (new Route 46).
    (25) Institute free bus service from University of Massachusetts via Maple Street to Hadley Shopping Centers (New Route 67).
    (26) Institute free bus service from University of Massachusetts via South Pleasant Street to East Hadley Road, South Amherst (New Route 68).
    (27) Increase frequencies of Five Colleges Inc. Bus Routes (54, 55 and 56).

4. Order new buses:

    (1) For Springfield, 36 each 45-passenger diesel-hydraulic with LSN injectors.
    (2) For University of Massachusetts, 10 each 31-passenger diesel-hydraulic with LSN injectors.

5. Design, print and distribute route maps, schedules, and other bus system information.

6. Negotiate park-and-ride sites at shopping centers.

YEAR MEASURES TO BE TAKEN

1974
(continued)

7. Begin bus stop marking program.
8. Plan transit marketing strategy and ride promotion activities.
9. Begin bus shelter program.
10. Institute Main Street bus lane experiment; study feasibility of Main Street bus mall.
11. Develop plans for bus priority treatments on State Street.
12. Initiate monitoring and surveillance program.

1975

1. Institute route changes as follows:
    (1) Route 8 (new 14), College-Walnut-Plumtree -- substitute new Route 14 from Plumtree to Amostown Road and new Route 15 from College via Walnut, State, Main, Vernon, I-291 Freeway, and Liberty Street to Springfield Plaza.
    (2) Institute special employment access Route 6, from Brightwood via State and Roosevelt to Monsanto.
    (3) Route 7 (new 11), State Street, increase frequency of service.
    (4) Route 22, Eastfield-Springfield via Wilbraham Road -- increase frequency of peak hour service.
    (5) Route 23, North Wilbraham-Springfield via Wilbraham Road -- increase frequency of peak hour service.
    (6) Route 25, Enfield-Springfield -- increase AM peak hour service.
    (7) Institute Enfield Mall Express (new Route 26).
    (8) Institute free bus service from University of Massachusetts to Longmeadow Drive, South Amherst (new Route 69).
2. Take delivery on 36 new 45-passenger buses, and put into service.
3. Take delivery on 10 new 31-passenger buses, and put into service.
4. Complete 9 bus shelters.
5. Continue bus stop marking program
6. Institute transit marketing programs and promotions.
7. Develop plans for Main Street Bus Mall, if feasible.
8. Order 12 each 31-passenger buses.
9. Order 33 each 45-passenger buses and registering fareboxes.
10. Terminate school bus cross-subsidy for carriers and begin assuming net operating cost with State aid.
11. Continue monitoring and surveillance program.

1976

1. Add the following cities and towns to the District:

    Chicopee
    Easthampton
    Hadley
    Holyoke
    Northampton
    South Hadley
    Williamsburg

YEAR MEASURES TO BE TAKEN

1976
(Continued)

2. Institute the following route changes:
    (1) Initiate Springfield Crosstown Route (new Route 7).
    (2) Holyoke Routes 2 and 3, Springfield Express and Chicopee Center Local -- substitute new local service (new Route 19) between Springfield and Holyoke via Springfield Hospital Medical Center and Chicopee Center.
    (3) Holyoke Route 4, Chicopee Falls -- extend through to East and Roosevelt in Springfield to form new Route 33.
    (4) Holyoke Routes 7 and 13, South Hadley Falls and Highlands -- combine to form new Route 37.
    (5) Holyoke Routes 9 and 10, Belchertown and Granby -- operate as agreed with those towns (new Route 38).
    (6) Holyoke Route 12, Northampton via Easthampton (new Route 39) -- institute additional Holyoke-Easthampton service (Route 40).
    (7) Holyoke Route 13, Highland Park -- rationalize service (new Route 41).
    (8) Holyoke Route 15, Oakdale -- extend to Bridge Street (new Route 42).
    (9) Institute Westfield-Holyoke service (new Route 44).
    (10) Initiate King Street Shuttle, Northampton, on experimental basis (Route 53).

3. Take delivery on 33 new 45-passenger buses and put into service.

4. Take delivery on 12 new 31-passenger buses and put into service.

5. Complete 10 bus shelters.

6. Complete bus stop marking program.

7. Continue transit marketing program.

8. Order 42 each 45-passenger buses and registering fareboxes.

9. Continue route and schedule information program.

10. Implement bus mall on Main Street (if feasible).

11. Implement bus priority treatments on State Street.

12. Continue monitoring and surveillance program.

1977

1. Take delivery of 42 new 45-passenger buses and put into service.

2. Order 36 each 45-passenger buses and registering fareboxes.

3. Order 18 each 31-passenger buses and registering fareboxes.

4. Complete 11 bus shelters.

5. Continue transit marketing program.

6. Continue route and schedule information program.

7. Continue monitoring and surveillance program.

1978

1. Take delivery of 36 new 45-passenger buses, and put into service.

2. Take delivery of 18 new 31-passenger buses, and put into service.

3. Continue bus shelter program.

4. Continue transit marketing program.

5. Continue route and schedule information program.

6. Continue monitoring and surveillance program.

APPENDIX K

ANALYSIS OF MASSACHUSETTS CARPOOLING AND EMPLOYER INCENTIVE PROGRAM

GENERAL

The draft of this report did not include a detailed analysis of the state carpooling program because at the time the draft was written there was insufficient information on the structure and scope of the program to perform any analysis. In the draft report no emission reduction was credited to the carpool program. Since preparation of the draft report, however, the Commonwealth of Massachusetts has developed a more detailed definition of the carpool program. This appendix will present an analysis of the present program as it would apply to the Springfield area.

DESCRIPTION

The analysis here is based upon the carpool program required by the Transportation Control Plan for the Boston Metropolitan area (40 FR 25151, 12 June 1975). The program required by the Boston regulations consists of two parts: (1) an employer incentive element that requires all employers of a certain size to provide incentives for employees to reduce the use of single-occupant automobiles for commuting to work, and (2) a carpooling program in which a state agency must provide assistance to employers in establishing and maintaining a carpool system. Most of the employer incentive measures required for the Boston area would have little or no impact on the Springfield area because they involve transit service, which is quite limited in the Springfield area. (Additional transit service in the Springfield area was analyzed in Section IV.) Consequently the element of the combined employer incentive and carpool programs that would have the greatest impact in the Springfield area would be the carpooling element.

For this analysis it is assumed that the carpooling element would be similar to that required for the Boston metropolitan area. This assumption has been confirmed through discussions with the Massachusetts Executive Office of Transportation and Construction (EOTC) and its consultants. In essence, the carpool program has the following major characteristics:

1. Each employer with 250 employees or more must conduct a carpooling program that assists employees in forming carpools and creates incentives for carpool formation. Incentives could consist of such actions as providing preferential parking.

2. EOTC will assist the employers in establishing and operating the carpool program. This will include supplying a manual that describes how to organize a carpool program and in addition includes providing advice and assistance through EOTC's consultants. In addition EOTC will arrange for an employer to obtain a computer program that can be used for carpool matching and will also perform the data processing on the state computer if the employer requests.

3. The goal of the program (including the employer incentive component of the Boston program) is to reduce the use of single occupant motor vehicles by 25 percent. That is, the goal is to encourage people who now drive alone to work to form carpools.

For the present analysis it has been assumed that the Springfield area carpool program will be essentially the same as the Boston program described above.

ANALYSIS OF SPRINGFIELD CARPOOL PROGRAM

Assumptions

This analysis assumes that carpooling will be the only significant element of the employer incentive program in the Springfield area, insofar as regional air quality is concerned. Also the analysis examines only the reduction in commuter travel and does not explicitly examine the problem of increased nonwork travel induced by the increased availability of cars because of carpooling.

Number of Employees

Table K-1 provides an estimate of the number of employees in the Springfield area who work for employers with 250 employees or more and who would therefore be involved in the carpool program. The estimate in the table is based upon census statistics but should be considered approximate. More precise data will be developed by EOTC and its consultants as the carpool program gets underway. The initial effort in the Springfield area is expected to be concentrated in Hampden County and Hampshire County because these two counties are more densely populated than Franklin County and present more potential for successful carpooling. As shown in the table there are approximately 74,000 employees in Hampden and Hampshire Counties who work for large employers. Franklin County has 7,000 employees, so that the AQSA has a total of approximately 81,000 employees that are likely to be exposed to the carpool program.

Carpooling Rate

Given the number of employees, an estimate was made of how much travel and emissions would be reduced. The basic analysis assumes that the program achieves its goal of reducing single occupant commuting by 25 percent. Table K-2 shows the results of the analysis.

If 74,000 employees (that is, the employees of large employers in Hampshire and Hampden Counties) are involved in the program and if the goal is achieved, total vehicle-miles of travel (VMT) will be reduced by 2.7 percent in the AQSA. For comparison, the table also shows the effect of smaller carpool programs. The data in the table can be used to indicate

Table K-1. EMPLOYEES OF LARGE EMPLOYERS IN SPRINGFIELD AQSA

Location	Total covered employees, 1972[a]	Estimated number of employees of large employers[b]
Hampden County	146,572	63,500
Hampshire County	26,407	10,000
Sub-total, Hampden and Hampshire Counties[c]	172,979	73,500
Franklin County	15,128	7,000
Total, three county area (Mass. portion of AQCR)	188,107	80,500

[a] Employees in scope of County Business Patterns reports plus Federal employees (p. 89 of 1972 report).

[b] Estimated by using (1) number of employers in various size categories in Table 18 of 1972 report, plus (2) Massachusetts average for number of employees per firm in each size category, from Table 1c. "Large employers" means those with 250 employees or more. Numbers are rounded.

[c] Hampden and Hampshire counties together form the Springfield-Chicopee-Holyoke Metropolitan State Economic Area (Table 3 of 1972 report).

Source: U.S. Department of Commerce, Bureau of the Census. County Business Patterns, 1972, Massachusetts. CBD-72-23. U.S. Government Printing Office, Washington.

Table K-2. EFFECT OF REDUCING COMMUTER USE OF SINGLE-OCCUPANT VEHICLES BY 25 PERCENT

Number of employees affected	Average auto-occupancy			Reduction in daily VMT	
	Among participants		In AQSA, after[c]	Amount	Percentage of AQSA total
	Before[b]	After[c]			
40,000	1.30	1.60	1.36	122,000	1.4
50,000	1.30	1.60	1.37	153,000	1.8
74,000	1.30	1.60	1.41	226,000	2.7

[a] Number of employees in employer incentive/carpooling programs. See text.

[b] Based upon 1974 survey of downtown Springfield (see also Appendix E).

[c] After achieving reduction of 25 percent in use of single-occupant vehicles for commuting.

the effectiveness of lesser amounts of carpooling than would be achieved if the goal is met.

DISCUSSION

The analysis shows that achievement of the goal would reduce VMT by 2.7 percent. Emissions of hydrocarbons would be reduced by approximately the same amount. This is likely to be the maximum effect that could be expected from a carpool program. Less effect would occur if some employers do not achieve their goal and if nonwork travel is increased. It is reasonable to expect that the success of the carpool program will depend a great deal upon external factors such as the price of gasoline, the availability of gasoline, and the degree to which employers provide more than the minimum effort for incentives required by the adopted regulations. None of these factors can be predicted at this time. Furthermore, the carpool program may not be fully operational in the Springfield area by the compliance date (whether the compliance date is 1 August 1976 or later). Thus it seemed reasonable to conclude that by the compliance date the carpool program will have produced no more than a 3 percent reduction in emissions, and probably less.

The amount of reduction from carpooling is small enough that it does not appear essential at this time to mandate any particulate amount of carpooling for air quality purposes. That is, there seems to be no technical basis for choosing a goal of, say, 25 percent rather than, say, 15 percent in the Springfield area. There are several other elements that affect whether a particular carpooling effort should be made mandatory, such as energy conservation and uniformity of policy among the various parts of the state. These considerations are beyond the present analysis so that no recommendation is made here regarding what level of carpooling should be the goal.

In conclusion, a carpool program could make a small contribution to reducing hydrocarbon emissions in the Springfield area. With a program similar to that in Boston, the maximum reduction is 2.7 percent in VMT and approximately the same reduction in emissions. It seems likely that there will be less effect than this, the amount depending upon the timing of the program, the actions of employers, and external factors such as gasoline prices and supply.

APPENDIX L

EMISSION FACTORS

LIGHT-DUTY VEHICLE (LDV) CO EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42

Low Altitude, Non-California Geographical Area

Incorporating the effect of the one-year extension of the interim standards announced on 5 March 1975.

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	86.5																				
1960	86.5	93.5																			
1961	86.5	93.5	94.0																		
1962	86.5	93.5	94.0	95.0																	
1963	86.5	93.5	94.0	95.0	96.0																
1964	86.5	93.5	94.0	95.0	96.0	97.0															
1965	86.5	93.5	94.0	95.0	96.0	97.0	98.0														
1966	86.5	93.5	94.0	95.0	96.0	97.0	98.0	99.0													
1967	86.5	93.5	94.0	95.0	96.0	97.0	98.0	99.0	99.0												
1968	67.8	63.7	67.6	70.6	73.6	76.6	79.6	82.6	82.6	82.6											
1969	61.7	64.2	65.4	68.4	71.4	74.4	77.4	80.4	83.4	83.4	83.4										
1970	47.6	53.2	56.0	58.5	61.0	63.5	66.0	68.5	71.0	73.5	73.5	73.5									
1971	39.6	51.1	53.5	56.0	58.5	61.0	63.5	66.0	68.5	71.0	73.5	73.5	73.5								
1972	36.9	36.9	39.0	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0	57.0	57.0	57.0							
1973		37.0	37.0	39.0	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0	57.0	57.0	57.0						
1974			37.0	37.0	39.0	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0	57.0	57.0	57.0					
1975				9.0	9.0	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0	18.0	18.0				
1976					9.0	9.0	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0	18.0	18.0			
1977						9.0	9.0	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0	18.0	18.0		
1978							2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	5.8	5.8	
1979								2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	5.8	5.8
1980									2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	5.8
1981										2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8
1982											2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6.	4.9	5.2	5.5
1983												2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2
1984													2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9
1985														2.8	2.8	3.1	3.4	3.7	4.0	4.3	4.6
1986															2.8	2.8	3.1	3.4	3.7	4.0	4.3
1987																2.8	2.8	3.1	3.4	3.7	4.0
1988																	2.8	2.8	3.1	3.4	3.7
1989																		2.8	2.8	3.1	3.4
1990																			2.8	2.8	3.1
1991																				2.8	2.8
1992																					2.8

The above tabulation takes into account the extension of the interim exhaust emission standards to model year 1977, but does not include any of the Administrator's recommendations for further changes in the emission factors for the years 1978-1981. For each calendar year there are data for 14 model year groups of cars. If a given calendar year is called year n, then the model year groups run from n-12 to n+1, inclusive.

LIGHT-DUTY TRUCK (LDT) CO EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
(Low Altitude, Non-California Geographical Area)

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	125.																				
1960	125.	125.																			
1961	125.	125.	125.																		
1962	125.	125.	125.	125.																	
1963	125.	125.	125.	125.	125.																
1964	125.	125.	125.	125.	125.	125.															
1965	125.	125.	125.	125.	125.	125.	125.														
1966	125.	125.	125.	125.	125.	125.	125.	125.													
1967	125.	125.	125.	125.	125.	125.	125.	125.	125.												
1968	63.0	66.5	70.0	73.5	77.0	80.5	84.0	87.5	87.5	87.5											
1969	60.8	64.3	67.8	71.3	74.8	78.3	81.8	85.3	88.8	88.8	88.8										
1970	51.0	53.5	56.0	58.5	61.0	63.5	66.0	68.5	71.0	73.5	73.5	73.5									
1971	51.0	53.5	56.0	58.5	61.0	63.5	66.0	68.5	71.0	73.5	76.0	76.0	76.0								
1972	42.8	42.8	45.0	47.2	49.4	51.6	53.8	56.0	58.2	60.4	62.6	64.8	64.8	64.8							
1973		42.8	42.8	45.0	47.2	49.4	51.6	53.8	56.0	58.2	60.4	62.6	64.8	64.8	64.8						
1974			42.8	42.8	45.0	47.2	49.4	51.6	53.8	56.0	58.2	60.4	62.6	64.8	64.8	64.8					
1975				27.0	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	42.0	42.0				
1976					27.0	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	42.0	42.0			
1977						27.0	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	42.0	42.0		
1978							9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8	19.8	19.8	
1979								9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8	19.8	19.8
1980									9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8	19.8
1981										9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8
1982											9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8
1983												9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8
1984													9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8
1985														9.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8
1986															9.8	9.8	10.8	11.8	12.8	13.8	14.8
1987																9.8	9.8	10.8	11.8	12.8	13.8
1988																	9.8	9.8	10.8	11.8	12.8
1989																		9.8	9.8	10.8	11.8
1990																			9.8	9.8	10.8
1991																				9.8	9.8
1992																					9.8

(See remarks at bottom of first page.)

HEAVY-DUTY VEHICLE (HDV) CO EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
(Low Altitude and California Geographical Areas)

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	238.																				
1960	238.	238.																			
1961	238.	238.	238.																		
1962	238.	238.	238.	238.																	
1963	238.	238.	238.	238.	238.																
1964	238.	238.	238.	238.	238.	238.															
1965	238.	238.	238.	238.	238.	238.	238.														
1966	238.	238.	238.	238.	238.	238.	238.	238.													
1967	238.	238.	238.	238.	238.	238.	238.	238.	238.												
1968	238.	238.	238.	238.	238.	238.	238.	238.	238.	238.											
1969	238.	238.	238.	238.	238.	238.	238.	238.	238.	238.	238.										
1970	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.									
1971	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.								
1972	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.							
1973		188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.	188.						
1974			167.	167.	168.	169.	170.	171.	172.	173.	174.	175.	176.	176.	176.	176.					
1975				167.	167.	168.	169.	170.	171.	172.	173.	174.	175.	176.	176.	176.	176.				
1976					167.	167.	168.	169.	170.	171.	172.	173.	174.	175.	176.	176.	176.	176.			
1977						167.	167.	168.	169.	170.	171.	172.	173.	174.	175.	176.	176.	176.	176.		
1978							117.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.	126.	126.	126.	
1979								117.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.	126.	126.	125.
1980									117.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.	126.	126.
1981										117.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.	126.
1982											117.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.
1983												117.	117.	118.	119.	120.	121.	122.	123.	124.	125.
1984													117.	117.	118.	119.	120.	121.	122.	123.	124.
1985														117.	117.	118.	119.	120.	121.	122.	123.
1986															117.	117.	118.	119.	120.	121.	122.
1987																117.	117.	118.	119.	120.	121.
1988																	117.	117.	118.	119.	120.
1989																		117.	117.	118.	119.
1990																			117.	117.	118.
1991																				117.	117.
1992																					117.

(See remarks at bottom of first page.)

MOTORCYCLE (MC) CO EMISSION FACTORS IN GM/MI, FROM ATTACHMENT NO. 1 TO AP-42 (DRAFT COPY)
Low Altitude Geographical Area

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	32.4																				
1960	32.4	32.4																			
1961	32.4	32.4	32.4																		
1962	32.4	32.4	32.4	32.4																	
1963	32.4	32.4	32.4	32.4	32.4																
1964	32.4	32.4	32.4	32.4	32.4	32.4															
1965	32.4	32.4	32.4	32.4	32.4	32.4	32.4														
1966	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4													
1967	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4												
1968	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4											
1969	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4										
1970	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4									
1971	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4								
1972	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4							
1973		32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4						
1974			32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4					
1975				32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4				
1976					32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4			
1977						28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4		
1978							28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	
1979								28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
1980									28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
1981										28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.4
1982											28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4	32.4
1983												28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4	32.4
1984													28.0	28.0	29.4	30.8	32.2	32.4	32.4	32.4	32.4
1985														2.1	2.1	2.3	2.5	2.7	2.9	3.1	3.3
1986															2.1	2.1	2.3	2.5	2.7	2.9	3.1
1987																2.1	2.1	2.3	2.5	2.7	2.9
1988																	2.1	2.1	2.3	2.5	2.7
1989																		2.1	2.1	2.3	2.5
1990																			2.1	2.1	2.3
1991																				2.1	2.1
1992																					2.1

(See remarks on first page.)

LIGHT-DUTY VEHICLE (LDV) HC EMISSION FAC TORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
(Low Altitude, Non-California Area)
Incorporating the effect of the one-year extension of the interim standards announced on 5 March.

CALENDAR YEARS

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	8.74																				
1960	8.74	8.67																			
1961	8.74	8.67	8.80																		
1962	8.74	8.67	8.80	8.90																	
1963	8.74	8.67	8.80	8.90	9.00																
1964	8.74	8.67	8.80	8.90	9.00	9.10															
1965	8.74	8.67	8.80	8.90	9.00	9.10	9.2														
1966	8.74	8.67	8.80	8.90	9.00	9.10	9.2	9.3													
1967	8.74	8.67	8.80	8.90	9.00	9.10	9.2	9.3	9.3												
1968	5.54	6.33	6.80	7.40	8.00	8.6	9.2	9.8	9.8	9.8											
1969	5.19	4.95	5.30	5.80	6.30	6.8	7.3	7.8	8.3	8.3	8.3										
1970	3.77	4.89	5.30	5.80	6.30	6.8	7.3	7.8	8.3	8.8	8.8	8.8									
1971	3.07	3.94	4.30	4.70	5.10	5.5	5.9	6.3	6.7	7.1	7.5	7.5	7.5								
1972	3.02	3.02	3.50	3.80	4.10	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.2	6.2							
1973		3.20	3.20	3.50	3.80	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.2	6.2						
1974			3.20	3.20	3.50	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.2	6.2					
1975				1.00	1.00	1.20	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0	3.0				
1976					1.00	1.00	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0	3.0			
1977						1.00	1.00	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0	3.0		
1978							0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75	2.0	2.25	2.25	2.25	
1979								0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75	2.0	2.25	2.25	2.25
1980									0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75	2.0	2.25	2.25
1981										0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75	2.0	2.25
1982											0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75	2.0
1983												0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50	1.75
1984													0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25	1.50
1985														0.27	0.27	0.36	0.45	0.54	0.63	0.72	1.25
1986															0.27	0.27	0.36	0.45	0.54	0.63	0.72
1987																0.27	0.27	0.36	0.45	0.54	0.63
1988																	0.27	0.27	0.36	0.45	0.54
1989																		0.27	0.27	0.36	0.45
1990																			0.27	0.27	0.36
1991																				0.27	0.27
1992																					0.27

LIGHT-DUTY TRUCK (LDT) HC EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude Non-California Geographical Area

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	17.0																				
1960	17.0	17.0																			
1961	17.0	17.0	17.0																		
1952	17.0	17.0	17.0	17.0																	
1963	17.0	17.0	17.0	17.0	17.0																
1964	17.0	17.0	17.0	17.0	17.0	17.0															
1965	17.0	17.0	17.0	17.0	17.0	17.0	17.0														
1966	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0													
1967	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0												
1968	6.3	7.1	7.9	8.7	9.5	10.3	11.1	11.9	11.9	11.9											
1969	4.7	5.3	5.9	6.5	7.1	7.7	8.3	8.9	9.5	9.5	9.5										
1970	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	9.6	9.6									
1971	3.7	4.2	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.7	8.7	8.7								
1972	3.4	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4	7.4	7.4							
1973		3.6	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	7.6	7.6						
1974			3.6	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	7.6	7.6					
1975				2.7	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	5.7	5.7				
1976					2.7	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	5.7	5.7			
1977						2.7	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	5.7	5.7		
1978							1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0	3.0	
1979								1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0	3.0
1980									1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.0
1981										1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
1982											1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8
1983												1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
1984													1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
1985														1.0	1.0	1.2	1.4	1.6	1.8	2.0	2.2
1986															1.0	1.0	1.2	1.4	1.6	1.8	2.0
1987																1.0	1.0	1.2	1.4	1.6	1.8
1988																	1.0	1.0	1.2	1.4	1.6
1989																		1.0	1.0	1.2	1.4
1990																			1.0	1.0	1.2
1991																				1.0	1.0
1992																					1.0

HEAVY-DUTY VEHICLE (HDV) HC EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude Non-California Geographical Area

MODEL YEARS	CALENDAR YEARS																				
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	35.4																				
1960	35.4	35.4																			
1961	35.4	35.4	35.4																		
1962	35.4	35.4	35.4	35.4																	
1963	35.4	35.4	35.4	35.4	35.4																
1964	35.4	35.4	35.4	35.4	35.4	35.4															
1965	35.4	35.4	35.4	35.4	35.4	35.4	35.4														
1966	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4													
1967	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4												
1968	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4											
1969	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.4	35.5										
1970	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.5	14.5	14.5									
1971	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.5	14.5	14.5								
1972	13.6	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.5	14.5	14.5							
1973		13.6	13.6	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.4	14.5	14.5	14.5	14.5						
1974			13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0	14.0	14.0					
1975				13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0	14.0	14.0				
1976					13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0	14.0	14.0			
1977						13.1	13.1	13.2	13.3	13.4	13.5	13.6	13.7	13.8	13.9	14.0	14.0	14.0	14.0		
1978							6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3	6.3	6.4	6.4	
1979								6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3	6.3	6.4	6.4
1980									6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3	6.3	6.4
1981										6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3	6.3
1982											6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3
1983												6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.3
1984													6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.2
1985														6.0	6.0	6.0	6.1	6.1	6.1	6.2	6.2
1986															6.0	6.0	6.0	6.1	6.1	6.1	6.2
1987																6.0	6.0	6.0	6.1	6.1	6.1
1988																	6.0	6.0	6.0	6.1	6.1
1989																		6.0	6.0	6.0	6.1
1990																			6.0	6.0	6.0
1991																				6.0	6.0
1992																					6.0

MOTORCYCLE (MC) HC EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude Non-California Geographical Area

MODEL YEARS	CALENDAR YEARS																				
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	8.5																				
1960	8.5	8.5																			
1961	8.5	8.5	8.5																		
1962	8.5	8.5	8.5	8.5																	
1963	8.5	8.5	8.5	8.5	8.5																
1964	8.5	8.5	8.5	8.5	8.5	8.5															
1965	8.5	8.5	8.5	8.5	8.5	8.5	8.5														
1966	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5													
1967	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5												
1968	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5											
1969	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5										
1970	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5									
1971	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5								
1972	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5							
1973		8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5						
1974			8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5					
1975				8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5				
1976					8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5			
1977						5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.5	8.5	8.5		
1978							5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.5	8.5	8.5	
1979								5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.5	8.5	8.5
1980									5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.5	8.5
1981										5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.5
1982											5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5	8.5
1983												5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	8.5
1984													5.0	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
1985														0.41	0.41	0.49	0.57	0.65	0.73	0.81	0.89
1986															0.41	0.41	0.49	0.57	0.65	0.73	0.81
1987																0.41	0.41	0.49	0.57	0.65	0.73
1988																	0.41	0.41	0.49	0.57	0.65
1989																		0.41	0.41	0.49	0.57
1990																			0.41	0.41	0.49
1991																				0.41	0.41
1992																					0.41

LIGHT-DUTY VEHICLE (LDV) NOX EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude Non-California Geographical Area

MODEL YEARS	CALENDAR YEARS																				
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	3.54																				
1960	3.54	3.34																			
1961	3.54	3.34	3.34																		
1962	3.54	3.34	3.34	3.34																	
1963	3.54	3.34	3.34	3.34	3.34																
1964	3.54	3.34	3.34	3.34	3.34	3.34															
1965	3.54	3.34	3.34	3.34	3.34	3.34	3.34														
1966	3.54	3.34	3.34	3.34	3.34	3.34	3.34	3.34													
1967	3.54	3.34	3.34	3.34	3.34	3.34	3.34	3.34	3.34												
1968	4.34	4.44	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32											
1969	5.45	5.00	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08										
1970	5.15	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35									
1971	5.06	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30								
1972	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55							
1973		3.10	3.10	3.30	3.5	3.7	3.9	4.1	4.30	4.5	4.7	4.9	5.1	5.1	5.1						
1974			3.10	3.10	3.3	3.5	3.7	3.9	4.10	4.3	4.5	4.7	4.9	5.1	5.1	5.1					
1975				3.10	3.1	3.2	3.3	3.4	3.50	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.1				
1976					3.1	3.1	3.2	3.3	3.40	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.1			
1977						3.1	3.1	3.2	3 .30	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.1		
1978							2.0	2.0	2.05	2.1	2.15	2.20	2.25	2.3	2.35	2.4	2.45	2.5	2.5	2.5	
1979								2.0	2.00	2.05	2.10	2.15	2.20	2.25	2.3	2.35	2.4	2.45	2.5	2.5	2.5
1980									2.00	2.0	2.05	2.10	2.15	2.2	2.25	2.3	2.35	2.4	2.45	2.5	2.5
1981										2.0	2.00	2.05	2.10	2.15	2.2	2.25	2.3	2.35	2.40	2.45	2.5
1982											1.00	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36
1983												1.00	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32
1984													1.00	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28
1985														1.00	1.00	1.04	1.08	1.12	1.16	1.20	1.24
1986															1.00	1.00	1.04	1.08	1.12	1.16	1.20
1987																1.00	1.00	1.04	1.08	1.12	1.16
1988																	1.00	1.00	1.04	1.08	1.12
1989																		1.00	1.00	1.04	1.08
1990																			0.40	0.40	0.41
1991																				0.40	0.40
1992																					0.40

LIGHT-DUTY TRUCK (LDT) NOX EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude,NonCalifornia Geographical Area

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	4.2																				
1960	4.2	4.2																			
1961	4.2	4.2	4.2																		
1962	4.2	4.2	4.2	4.2																	
1963	4.2	4.2	4.2	4.2	4.2																
1964	4.2	4.2	4.2	4.2	4.2	4.2															
1965	4.2	4.2	4.2	4.2	4.2	4.2	4.2														
1966	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2													
1967	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2												
1968	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9											
1969	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3										
1970	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2									
1971	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2								
1972	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3							
1973		4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.4	6.4						
1974			4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.4	6.4					
1975				4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.4	6.4				
1976					4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.4	6.4			
1977						4.4	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.4	6.4		
1978							2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7	2.75	2.8	2.8	2.8	
1979								2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7	2.75	2.8	2.8	2.8
1980									2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7	2.75	2.8	2.8
1981										2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7	2.75	2.8
1982											2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7	2.75
1983												2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65	2.7
1984													2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6	2.65
1985														2.3	2.3	2.35	2.4	2.45	2.5	2.55	2.6
1986															2.3	2.3	2.35	2.4	2.45	2.5	2.55
1987																2.3	2.3	2.35	2.4	2.45	2.5
1988																	2.3	2.3	2.35	2.4	2.45
1989																		2.3	2.3	2.35	2.4
1990																			2.3	2.3	2.35
1991																				2.3	2.3
1992																					2.3

HEAVY-DUTY VEHICLE (HDV) NOX EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude andCalifornia Geographical Area

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	6.8																				
1960	6.8	6.8																			
1961	6.8	6.8	6.8																		
1962	6.8	6.8	6.8	6.8																	
1963	6.8	6.8	6.8	6.8	6.8																
1964	6.8	6.8	6.8	6.8	6.8	6.8															
1965	6.8	6.8	6.8	6.8	6.8	6.8	6.8														
1966	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8													
1967	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8												
1968	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8											
1969	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8										
1970	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0									
1971	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0								
1972	12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0							
1973		12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0						
1974			12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0					
1975				12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0				
1976					12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0			
1977						12.5	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0	13.0		
1978							11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.0	13.0	13.0	13.0	
1979								11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.0	13.0	13.0	13.0
1980									11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.0	13.0	13.0
1981										11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.0	13.0
1982											11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.0
1983												11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0
1984													11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8
1985														11.4	11.4	11.6	11.8	12.0	12.2	12.4	12.6
1986															11.4	11.4	11.6	11.8	12.0	12.2	12.4
1987																11.4	11.4	11.6	11.8	12.0	12.2
1988																	11.4	11.4	11.6	11.8	12.0
1989																		11.4	11.4	11.6	11.8
1990																			11.4	11.4	11.6
1991																				11.4	11.4
1992																					11.4

MOTORCYCLE (MC) NOX EMISSION FACTORS IN GM/MI, FROM SUPPLEMENT 5 & ATTACHMENT 1 TO AP-42
Low Altitude -- California Geographical Area

CALENDAR YEARS

MODEL YEARS	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1959	0.2																				
1960	0.2	0.2																			
1961	0.2	0.2	0.2																		
1962	0.2	0.2	0.2	0.2																	
1963	0.2	0.2	0.2	0.2	0.2																
1964	0.2	0.2	0.2	0.2	0.2	0.2															
1965	0.2	0.2	0.2	0.2	0.2	0.2	0.2														
1966	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2													
1967	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2												
1968	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2											
1969	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2										
1970	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2									
1971	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2								
1972	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2							
1973		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2						
1974			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2					
1975				0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
1976					0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2			
1977						0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		
1978							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
1979								0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1980									0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1981										0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1982											0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1983												0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1984													0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1985														0.40	0.40	0.4	0.4	0.4	0.4	0.4	0.4
1986															0.40	0.4	0.4	0.4	0.4	0.4	0.4
1987																0.4	0.4	0.4	0.4	0.4	0.4
1988																	0.4	0.4	0.4	0.4	0.4
1989																		0.4	0.4	0.4	0.4
1990																			0.4	0.4	0.4
1991																				0.4	0.4
1992																					0.4

LDV CRANKCASE HC EMISSIONS BY MODEL YEAR (ALL AREAS EXCEPT CALIFORNIA)

Model Year	Hydrocarbon Emissions (GM/MI)
Pre-1963	4.1
1963-1967	0.8
Post-1967	0.0

LDV EVAPORATIVE HC EMISSIONS BY MODEL YEAR (LOW ALTITUDE, NON-CALIFORNIA)

Pre-1970	2.53
1970	2.53
1971	1.78
1972 and later	1.76

LDT CRANKCASE AND EVAPORATIVE EMISSIONS BY MODEL YEAR (LOW ALTITUDE)

(The category LDT is assumed to include 2/3 less than 6,000 lb GVW and 1/3 of 6,000 to 8,500 lb GVW.)

Pre-1963	7.0
1963-1967	4.8
1968-1970	2.53
1971	2.03
1972-1977	2.01
Post-1977	1.76

HDV CRANKCASE AND EVAPORATIVE HC EMISSIONS BY MODEL YEAR (LOW ALTITUDE)

Pre-1968	7.7
1968-1972	2.5
Post-1972	2.0 (?)

Source: Draft Supplement No. 5 and Attachment No. 1, AP-42, October 1974.

COMBINED CRANKCASE AND EVAPORATIVE HYDROCARBONS EMISSION FACTORS

LOW ALTITUDE GEOGRAPHICAL AREA

MODEL	HYDROCARBONS EMISSIONS (GM/MI)			
YEAR	LDV	LDT	HDV	MC
1957	6.63	7.0	7.7	0.72*
1958	6.63	7.0	7.7	
1959	6.63	7.0	7.7	
1960	6.63	7.0	7.7	
1961	6.63	7.0	7.7	
1962	6.63	7.0	7.7	
1963	3.33	4.8	7.7	
1964	3.33	4.8	7.7	
1965	3.33	4.8	7.7	
1966	3.33	4.8	7.7	
1967	3.33	4.8	7.7	
1968	2.53	2.53	2.5	
1969	2.53	2.53	2.5	
1970	2.53	2.53	2.5	
1971	1.78	2.03	2.5	
1972	1.76	2.01	2.5	
1973	1.76	2.01	2.0	
1974	1.76	2.01	2.0	
1975	1.76	2.01	2.0	
1976	1.76	2.01	2.0	
1977	1.76	2.01	2.0	
1978	1.76	1.76	2.0	
1979	1.76	1.76	2.0	
1980	1.76	1.76	2.0	
1981	1.76	1.76	2.0	
1982	1.76	1.76	2.0	
1983	1.76	1.76	2.0	
1984	1.76	1.76	2.0	
1985	1.76	1.76	2.0	
1986	1.76	1.76	2.0	
1987	1.76	1.76	2.0	
1988	1.76	1.76	2.0	
1989	1.76	1.76	2.0	
1990	1.76	1.76	2.0	
1991	1.76	1.76	2.0	0.72

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*This value is used for all model years. It is a weighted average based on the assumed distribution of 60 percent 4-stroke engines and 40 percent 2-stroke engines.

Source: Source of the basic data used to develop the above lists is the Draft Supplement No. 5 and Attachment No. 1 to EPA Publication AP-42, dated October 1974.